DESIGN OF A COMPUTER-ASSISTED COASTAL INFORMATION SYSTEM

PHASE II - PRELIMINARY DESIGN

OFFICE OF NAVAL RESEARCH
CONTRACT N00014-68-C-0164/P001

SEPTEMBER 15, 1969

MATRIX

Reproduction in whole or in part is permitted for any purpose of the United States Government. This document has been approved for public release and sale; its distribution is unlimited.

DESIGN OF A COMPUTER ASSISTED COASTAL INFORMATION SYSTEM

PHASE II

(Office of Naval Research Contract N00014-68-C-0164/002)

September 15, 1969

Robert D. Campbell

MATRIX RESEARCH COMPANY
Area Systems Division
421 King Street
Alexandria, Virginia 22314

PREFACE

The report of the past year's work is contained in Chapters 1 through 6. A summary reporting the entire project (two years) is appended. It is not intended to be an abstract of the final reports of Phases I and II. Instead, it is an independent statement of the rationale of the project and our own evaluation of progress.

A number of people worked on the project this past year. Donald Dellinger (SCI) and Donald Schudel carried out the bulk of the interviewing. They reported on a standard form, copies of all these reports have been given to the office of Geography Programs, ONR. Robert Smith and Fenn Sykes were consultants. Mr. Sykes examined all the systems statements for consistency, and his comments and suggestions were particularly helpful in the development of the ecology and information system descriptions. Mr. Smith examined the weapons systems acquisition process for its use of environmental data. Whatever clarity and distinction the illustrations have must be credited to the scientific artistry of Sheldon Shenk.

We are especially grateful to personnel of the office of Geography Programs for their continual support in procuring documents and paving the way for our visits to naval offices.

TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

Progress on this year's work is summarized in the form of four "lessons learned": (1) there is a good deal of evidence within Navy that environmental impact is a significant factor in effectiveness of naval operations; (2) the interaction focus is with weapons systems; therefore, the basis for understanding environmental impact is naval ecology -- the science of the interactions between environment and men-and-machines in discrete naval activities; (3) naval ecology provides the framework which relates the four basic naval functions, and it clarifies the distinctions made between research and development, both of which are relevant in weapons systems terms, but in different fashions; and (4) a coastal information system is such a powerful addition to any organization, serving not only the decision-making process but also the process of developmental change, that it must be carefully developed in accordance with both the scientific structure of naval ecology and the functional and organizational patterns of Navy.

Investigations leading to these lessons led us to postulate: (a) a model of naval ecology, and (2) a description of a theoretical coastal information system. In effect, these models constitute our major findings: (1) that it is possible to begin to build from present knowledge an aggregated and extrapolatable body of information concerning the effect

of environment on a given naval operation; and (2) that it is possible now to design and introduce a partial, prototype coastal information system which will produce command level outputs to all four naval functions for an amphibious operation.

CHAPTER 1

INTRODUCTION

While there is a great temptation to report progress on the basis of the projections made in proposals, it seems at this point in the study more useful to recapitulate in terms of the "lessons learned". Despite the systems approach used in this project, it is still research, not development. One starts not with the ultimate idea of constructing an information system, but rather with the idea of attempting to find out what an information system must do and whether in fact it seems feasible after that to do it or not. It is on the basis of what we have learned about both the ideal world of naval ecology and the real world of naval organization that we must evaluate the probability that a useful coastal information system ought to be, and can be, innovated by Navy.

Lessons Learned

The following four lessons constitute our basis for estimating the situation and projecting future work.

(1) The importance of environmental impact. There is abundant evidence that environment often plays a key role in the success or failure (or more often partial success or partial failure) of a naval operation, just as environmental constraints consistently degrade the performance of men and machines in day-to-day civilian activities in all cultures.

The probability is great that systematic discovery and application of principles of environmental impact would upgrade performance of men and machines and would be cost-effective for Navy, and there are good but not sufficient reasons why this has not been done.

(2) <u>The basic nature of a knowledge of naval ecology</u>. Naval ecology -- the science of the interactions between environment and men-and-machines in discrete naval activities -- is inadequate at the present time to provide a framework for a responsive coastal information system, although much of the data basic to such a framework apparently exists.

For decades this whole interdisciplinary area has been investigated sporadically, recognized in some ways and not at all in others, and in general not dealt with systematically at all. The result is that the Navy has a great many "test sites" but adequate methods of environmental testing -- i.e., determining the efficiency of operation of a given person or kind of materiel in a given environment -- appear to vary from one site to another. It has a fleet weather service which transmits a great deal of environmental information, some of it extremely valuable, some not very useful, but meanwhile all kinds of vital environmental data are not even collected, let alone disseminated. It has the capability of photographing large areas from the air before an operation, but little capability of handling all of these visual data

once they are collected. During the past year a number of people in Navy laboratories were interviewed -- people responsible for perfecting the design and development of weapons systems. Their estimates of the kinds of environmental information they needed varied from nothing to everything, depending upon their backgrounds and experience. Very few made any reference to the requirement to translate environmental data into environmental effects language. On the other hand, reports from these laboratories show a considerable awareness of effect of environment, and effects terminology is used constantly in these reports.

The fact is that a great deal is already known about naval ecology if it were systematically pulled together and organized. We believe most military personnel and laboratory scientists and engineers would be surprised to learn how much is known, based largely on their own efforts but never coordinated.

(3) <u>Distinction between "research" and "development"</u>. One reason for the foregoing statement is that organizations (i.e., the Navy) tend to be structured in terms of discrete categories of function and knowledge, and naval ecology means in effect <u>all</u> of the interactions between the many physical and cultural facets of coastal areas and the things and people and activities that make up naval operations. Therefore, all functional categories of Navy and their operating subdivisions

may have something to contribute to or learn from naval ecology. It is in effect an information base as pervasive as intelligence or logistics and perhaps should be institutionalized in new subcategories of present functional institutions and focused as an informational activity. One cogent reason for arriving at such a conclusion is that the research and development functions are organizationally distinct in Navy and apparently* perceived by people in development, and in operations as well, as relatively unrelated and directed toward different goals.

The distinctions are these: development takes place in Navy laboratories and in industry, while research takes place largely outside Navy, sponsored by ONR. Development is weapons systems oriented, while research is not, although there is a schizophrenic feeling in ONR about the extent to which "basic" research can be made to demonstrate naval "relevance". Development produces hardware in direct response to Fleet requirements (through CNO and the Systems Command), while research produces reports largely in response to unsolicited proposals from the scientific community. (It would be interesting to know how much ONR-supported research is a direct response to laboratory requirements, and how much use laboratories made of ONR reports.)

---

* We have not talked to all people in development, nor in operations, obviously, but this was a recurrent and not unexpected comment. How people in ONR view this we do not know.

It would appear to the outsider that while there are distinctions between research and development, there ought to be a high degree of coordination of these functions supported by one organization. Yet the outsider does not have to deal with the hard facts of organizational life. It is often easier to add a new, integrating activity than to change the patterns of an old activity. In any case, the distinction between research and development functions is not unique: there are also communications breakdowns between development and evaluation, between evaluation and operations, between research and strategic planning.

One significant aspect of this "lesson" is that an information system has tremendous potential for introducing change in organizations, as will be noted later.

(4) The key role of a coastal information system. It became apparent that an information system of the sort we hoped to design would provide more than data on environmental impact to potential users of such data: it would perhaps just as importantly forge a communications link among the functional aspects of Navy, and among its diversely-oriented groups of personnel. We began to think of such a system not as the product of change, but rather as the instrument of change, for it could override functional organizational jurisdictions without overriding the responsibilities of those who ran them.

But to function in this fashion, an information system must be accepted by the people who will use it: it must therefore be at one and the same time comprehensible in terms of present naval practices and structured in a highly logical fashion. The answer to doing this is to make the logic of structure the logic of naval ecology, on the one hand, and to introduce the system in manageable pieces. Our representation of such a system is an attempt to be consistent with structured views of naval ecology and the processes of information handling in Navy.

<u>Summary</u>. The environment does exercise an influence, often important, sometimes critical, on the men, machines, and materiel of naval operations. The core of what is important to a Navy-responsive coastal information system is the environment-weapons systems-operations relationship, or how environment effects naval operations. We have called it naval ecology. Knowledge about the relationship is applied to different kinds of decision-making in different functional areas of Navy and to different levels of the same function. Therefore, the information system must accommodate and by so doing relate all functions in terms of the common naval mission which is the successful use of weapons systems in support of U. S. policy. To introduce such a system means winning the active participation of elements of all functions by demonstrating the value of participation to each function individually.

CHAPTER 2

THE IMPORTANCE OF ENVIRONMENTAL IMPACT

Feasibility of an information system involves some kind of effectiveness evaluation. While our first objective was to test feasibility of design, actual utility quickly became an important adjunct of the investigation, because so many people in Navy did not recognize environmental impact of significance to operations or of interest, generally, to anyone beyond the design engineer. The engineer, on the other hand, will meet the constraints he can and suggest some operational adaptations for those he can't. So a question that was frequently implicit in our conversations was this: "Is environmental impact on weapons system design, development, deployment, maintenance, and operation significant infrequently, occasionally, or often enough to worry about? Because, if it is important often enough to worry about, why hasn't it been worried about, in any of the services, in an organized way?" We will attempt to answer both questions.

Measures of Importance of Environmental Impact on Military Operations

Evidence of the importance of environment is given, based on studies and military documents which specify impact, and organizations involved in some aspect of the problem.

Studies. There have been a great many studies of the effect of environment on either military operations or on men in a variety of activities or on materiel of various sorts. The author of this report directed a three year study of the effect of environment on military operations in World War II and Korea as revealed in military records (Campbell, et al. 1957). Some of the conclusions reported in a statistical analyses of the data from records were as follows:[1]

* For a given _location_ the distribution of effects is a function of the _operation_ being conducted, with a few exceptions.

* The distribution of _effects_ on both materiel and _personnel_, in general, is a function of the location in which a specific _operation_ is conducted. For example, when a transportation operation is conducted in Northern France or Northern Germany, of the effects observed on materiel, the probability is .72 that the effect _movement inhibition_ will be observed.

* It seems true from the data that the Accomplishment of Operation distributions are functions of Magnitude of Effect, but that they are influenced by some factors which are not working strictly on Magnitude of Effect. For example, it seems reasonable to suppose that other things besides environmental elements will be acting to affect the outcome of a military operation -- such things as size of forces involved, psychological and morale factors, etc. It is felt, therefore, that Accomplishment of Operation as a coordinate gives sufficiently more information than Magnitude

[1] McCall, C. H., Jr., _The Nine-Coordinate Probability Model Describing Environment-Military Operations Relationships_, The Historical Records Project, The George Washington University, Washington, D. C., September 1957.

of Effect to warrant its use in future analyses. There appears to be some justification for calling Magnitude of Effect a tangible measure of known environmental factors influencing an operation and for calling Accomplishment of Operation a measure based on these factors plus all others which may also be acting in the given military situation.

This study was preceded by Project ENVANAL (Dunlap Associates) and followed by Project DUTY (University of Denver) -- both long term projects relating environment to military materiel and men and military operations. (See bibliography)

Among design engineers and scientists, in particular, there is recognition of the impact of environment. Reports from the many Navy laboratories and test centers of various sorts are evidence of this, and it is especially true of civil engineering processes and products. The Naval Civil Engineering Laboratory at Port Hueneme, in its January, 1968, GUIDE TO NCEL TECHNICAL DOCUMENTS, listed a very high proportion of environmental impact studies, a sample of which are shown (Figure 1). We went through the index alphabetically and picked, more or less at random, samples of topics which showed the impact relationship (Figure 2). From "Antarctic Regions" to "eddy currents" to "floating docks" to "pontoons" to "trafficability" to "storage" to "wood preservative" -- the subjects indicate the environment-equipment/men/materiel-operations-relationships and their applications. The Defense

R-284-1
STRUCTURES IN DEEP OCEAN. ENGINEERING MANUAL FOR UNDERWATER CONSTRUCTION. CHAPTER 1. INTRODUCTION. PROJ. Y-F015-01-01-001A. MARCH 1964. W.J. TUDOR. AD 600306.

THE OBJECTIVE OF THIS MANUAL IS TO PROVIDE INFORMATION ON ENVIRONMENTS, SYSTEMS, AND TECHNIQUES RELATIVE TO CONSTRUCTION IN DEEP OCEAN AREAS. DEVELOPMENTS IN NAVAL WARFARE HAVE PLACED EMPHASIS ON THE DEEP OCEAN AREAS AS AN OPERATING ENVIRONMENT. CONSEQUENTLY, IN SUPPORT OF THESE OPERATIONS, THERE IS A NEED FOR KNOWLEDGE CONCERNING METHODS OF CONSTRUCTION IN THE DEEP OCEAN. IT IS REALIZED THAT THESE METHODS CAN DIFFER MARKEDLY FROM THOSE USED IN CONSTRUCTION ON LAND. THEREFORE, IN THIS RELATIVELY NEW FIELD MANY DEFICIENCIES EXIST WHICH CAN BE REDUCED ONLY BY RESEARCH AND DEVELOPMENT. THIS WILL REQUIRE CONSIDERABLE TIME. HOWEVER, IN THE INTERIM, CONSTRUCTION MUST CONTINUE. TOWARD MAKING THIS AS EFFECTIVE AS FEASIBLE, EXISTING INFORMATION HAS BEEN REVIEWED AND DIGESTED, AND IS PRESENTED IN THIS MANUAL. INFORMATION HAS BEEN PROVIDED BY SCIENTISTS, ENGINEERS, AND OFFSHORE OPERATORS, ESPECIALLY THOSE ENGAGED IN PETROLEUM PRODUCTION. DEEP OCEAN CONSTRUCTION IS A LOGICAL EXTENSION OF THE RESPONSIBILITY OF THE BUREAU OF YARDS AND DOCKS FOR CONSTRUCTION OF NAVAL FACILITIES. THIS MANUAL SHOULD ASSIST IN MEETING THIS RESPONSIBILITY BY PROVIDING ENGINEERS, CONSTRUCTORS, PLANNERS, AND OTHERS ENGAGED IN DEEP OCEAN CONSTRUCTION WITH PERTINENT INFORMATION.

R-284-2
STRUCTURES IN DEEP OCEAN. ENGINEERING MANUAL FOR UNDERWATER CONSTRUCTION. CHAPTER 2. DEEP-OCEAN ENVIRONMENT. PROJ. Y-F015-01-01-001A. MARCH 1964. W.J. TUDOR. AD 600307.

TECHNOLOGICAL DEVELOPMENT INDICATES THAT MUCH OF THE NAVAL WARFARE OF THE FUTURE WILL OCCUR AT DEEP OCEAN DEPTHS. CONCURRENTLY, THERE IS A NEED FOR ADDITIONAL KNOWLEDGE OF METHODS FOR CONSTRUCTION IN DEEP OCEANS. THEREFORE, THE OBJECTIVE OF THIS REPORT IS TO PROVIDE INFORMATION ON ENVIRONMENTS AND TO DESCRIBE SYSTEMS AND TECHNIQUES DEVELOPED FOR CONSTRUCTION IN DEEP OCEAN AREAS.

THIS CHAPTER CONTAINS ENVIRONMENTAL KNOWLEDGE PERTAINING TO WAVES AND CURRENT ACTION, SALINITY AND TEMPERATURE VARIATIONS, BOTTOM TOPOGRAPHY, MARINE ORGANISMS, CHEMICAL AND PHYSICAL PROPERTIES OF SEA WATER, ETC. IN ORDER TO TREAT ALL OF THIS DATA, IT WAS CONVENIENT TO FIRST LOCATE AND DISTINGUISH THE OCEANS AND THEN DESCRIBE THE OCEAN BOTTOM AND OCEAN CONTENTS BEFORE FINALLY DESCRIBING THE DYNAMIC FACTORS ACTING ON THE OCEANS.

R-079
WAREHOUSE AND PRESERVATION METHODS AND ECONOMICS FOR STORING MATERIEL. PROJ. Y-F015-04-004. JUNE 1960. R. J. ZABLODIL, J. C. KING. AD 239745, PB 149233.

NCEL IS CONDUCTING A FIVE YEAR STORAGE TEST PROGRAM TO EVALUATE VARIOUS STORAGE ENVIRONMENTS AND PRESERVATION LEVELS FOR MATERIEL UNDER THE BUREAU OF YARDS AND DOCKS TECHNICAL COGNIZANCE.

SIMILAR PAIRED ITEMS OF MILITARY EQUIPMENT WERE STORED IN DIFFERENT STORAGE ENVIRONMENTS - AN OPEN AIR SLAB, A SHED, A STANDARD WAREHOUSE, A 40 PERCENT RH WAREHOUSE, AND A 50 PERCENT RH WAREHOUSE. ONE OF EACH PAIR HAD LIGHT DOMESTIC PRESERVATION TREATMENT AND THE OTHER FULL CONTACT PRESERVATION TREATMENT. DETERIORATION WAS PERMITTED TO DEVELOP AT ITS NATURAL RATE IN EACH ENVIRONMENT. PERIODIC INSPECTIONS WERE USED TO DETERMINE THE STORAGE PROTECTION AFFORDED BY EACH ENVIRONMENT.

RESULTS OF 2-1/2 YEARS OF STORAGE SHOW THAT PROTECTION IS POOR IN OPEN AIR, FAIR IN THE SHED, GOOD IN THE STANDARD WAREHOUSE, AND BETTER IN THE RH WAREHOUSES.

THE NAVY STANDARD 40-FT X 100-FT PREFABRICATED METAL BUILDING APPEARS GENERALLY SATISFACTORY FOR ADVANCED BASE DEHUMIDIFIED WAREHOUSING, BUT IT HAS TOO MANY JOINTS TO BE EASILY SEALED.

R-209
AIR FORCE ARCTIC BUILDING. PROJ. AFS 59-00-9. JUNE 1962. J. P. COSENZA. 63 P. OUO. AD 611389.

A PREFABRICATED, PANELIZED, 16- BY 28-FOOT STRUCTURE WAS DESIGNED AND BUILT FOR THE U. S. AIR FORCE BY THE NAVAL CIVIL ENGINEERING LABORATORY. THE BUILDING, MADE OF STEEL-FACED HONEYCOMB-CORE PANELS WITH PLYWOOD EDGES, WAS DESIGNED FOR USE IN THE DEW SYSTEM IN THE ARCTIC.

THE PROTOTYPE WAS TESTED AT THE CLIMATIC LABORATORY AT EGLIN AIR FORCE BASE, FLORIDA, UNDER A VARIETY OF CONTROLLED CLIMATIC CONDITIONS, INCLUDING WIND, RAIN, AND SNOW. TESTS INCLUDED ERECTION, HEAT LOSS, STRUCTURAL, AND WEATHERTIGHTNESS, AND PACKAGING STUDIES. THE BUILDING HAS A LOW COEFFICIENT OF HEAT TRANSMISSION AND CAN WITHSTAND A 125-MPH WIND LOAD, A 100-PSF SNOW LOAD, AND RACKING.

THREE YEARS AFTER FABRICATION, THE CRATED PROTOTYPE WAS REMOVED FROM STORAGE AND INSPECTED. THIS INSPECTION REVEALED SUCH EXTENSIVE DETERIORATION OF THE STEEL FACES AND EDGES ON THE PANELS, THAT THE PROTOTYPE COULD NOT BE ASSEMBLED OR REPAIRED. IT WAS CONCLUDED THAT THIS BUILDING MUST BE REDESIGNED, USING CORROSION-RESISTANT MATERIAL IN ORDER TO ACHIEVE A 25-YEAR LIFE.

R-300
A TEMPORARY POLAR CAMP. PROJ. Y-F015-11-104. MARCH 1964. G. E. SHERWOOD. 124 P. AD 436217.

A TEMPORARY POLAR CAMP WAS DEVELOPED TO PROVIDE COMFORTABLE LIVING CONDITIONS FOR PERIODS UP TO 5 YEARS IN THE ARCTIC AND ANTARCTIC. THE CAMP DESIGN INCLUDED STRUCTURES, AIR CONDITIONING, WATER SUPPLY, SANITATION, AND OTHER FACILITIES INTEGRATED TO FORM A UNIFIED FUNCTIONAL COMPONENT. THE BASIC CAMP WAS DESIGNED FOR 50-MAN OCCUPANCY AND EXPANSION IN 50-MAN INCREMENTS TO A 200-MAN CAPACITY. EACH MAN IS PROVIDED WITH AN INDIVIDUAL ROOM. DOUBLE BUNKS MAY BE USED, WITH TWO MEN SHARING A ROOM, TO INCREASE THE CAMP CAPACITY FOR SHORT PERIODS.

THE BUILDING UNIT IS THE MODIFIED T-5, VARIOUSLY OUTFITTED FOR USE AS QUARTERS, MESSING, GALLEY, UTILITIES ADMINISTRATION, COMMUNICATIONS, RECREATION, MEDICAL, HEAD, LAUNDRY, AND STORAGE FACILITIES. A DUPLEX CONCEPT IS USED BY WHICH TWO BUILDING UNITS ARE JOINED END TO END BY A SERVICE CORE WHICH HOUSES AN AIR-CONDITIONING SYSTEM, HEAD, AND LAUNDRY, TO FORM A BASIC BUILDING. A T-5M MAINTENANCE SHELTER IS PROVIDED FOR MAINTENANCE OF CAMP EQUIPMENT.

SPECIFICATIONS AND REDUCED SCALE DRAWINGS FOR CAMP HAVE BEEN PUBLISHED IN NCEL TECHNICAL NOTE N-540, 'SPECIFICATIONS FOR A TEMPORARY POLAR CAMP.'

N-907
THE EFFECT OF ENVIRONMENT ON THE CORROSION OF METALS IN SEA WATER -- A LITERATURE SURVEY. PROJ. Y-F020-03-01-003 JULY 1967. H. A. PORTE. AD 820155L

THE U. S. NAVAL FACILITIES ENGINEERING COMMAND IS INTERESTED IN DEVELOPING METHODS TO COMBAT METALLIC CORROSION AS A MEANS OF REDUCING MAINTENANCE COSTS OF THE NAVAL SHORE ESTABLISHMENT.

A LITERATURE SURVEY WAS MADE TO DETERMINE THE EFFECT OF ENVIRONMENTAL VARIABLES ON THE CORROSION RATES OF METALS SUBMERGED IN SEA WATER. THE MOST IMPORTANT VARIABLES WERE FOUND TO BE DISSOLVED OXYGEN CONCENTRATION, VELOCITY , AND TEMPERATURE. OTHER FACTORS WHICH INFLUENCE THE CORROSION RATES ARE PH, SALINITY, AND MICRO-ORGANISMS. IT IS RECOMMENDED THAT A COORDINATED RESEARCH PROGRAM, CONSISTING OF BASIC RESEARCH STUDIES AND CORROSION TESTING, BE INITIATED IN CONTROLLED SEA WATER ENVIRONMENTS.

NOY-73232
A REVIEW AND EVALUATION OF RESEARCH RELATED TO TRAFFICABILITY OF BEACHES. SERIES 99, ISSUE 1. JULY 1953. UNIVERSITY OF CALIFORNIA, BERKELEY.

THE PURPOSE OF THIS INVESTIGATION WAS TO SURVEY, SUMMARIZE, AND ANALYZE EXISTING DATA RELATED TO BEACH TRAFFICABILITY AND TO INDICATE WHAT RESEARCH IS NEEDED FOR THE DEVELOPMENT OF TECHNIQUES WHICH WILL PERMIT APPRAISAL OF BEACH TRAFFICABILITY WITH GREATER PRECISION THAN IS NOW POSSIBLE.

THE MAIN OBJECTIVES OF THE RESEARCH IN TRAFFICABILITY HAVE BEEN (1) TO IMPROVE THE TRAFFICABILITY CHARACTERISTICS OF MILITARY VEHICLES AND (2) TO DEVELOP TECHNIQUES FOR PREDICTING THE PERFORMANCE OF SOILS FOR THE MOVEMENT OF GIVEN VEHICLES. BUT SINCE THE RELATIONSHIP OF VEHICLE AND SOIL IS INVOLVED IN BOTH, THE TWO TYPES OF INVESTIGATIONS OFTEN BECOME CONCERNED WITH SIMILAR PROBLEMS.

R-155
TECHNICAL DATA FROM DEEP FREEZE I, II, AND III REPORTS (1955 TO 1958). PROJ. Y-F015-11-002. APRIL 1961. R. C. COFFIN. OUO. AD 256459.

THIS REPORT IS A COMPILATION OF TECHNICAL DATA OBTAINED PRINCIPALLY FROM THE FOURTEEN VOLUMES OF REPORTS PREPARED BY MOBILE CONSTRUCTION BATTALION (SPECIAL) FOR OPERATIONS DEEP FREEZE I, II, III. SUPPLEMENTAL INFORMATION WAS OBTAINED FROM CORRESPONDENCE AND SITUATION REPORTS ORIGINATED BY DEEP FREEZE FORCES, AND REPORTS OF MILITARY AND PROFESSIONAL CIVILIAN OBSERVERS, WHICH ARE LISTED IN THE REFERENCES AND BIBLIOGRAPHY.

THE INFORMATION IS GROUPED INTO FIFTEEN GENERAL TECHNICAL SUBJECT AREAS, WHICH ARE SUBDIVIDED INTO SPECIFIC PROBLEM AREAS. WITHIN THE PROBLEM AREAS THE DATA ARE PRESENTED BY INDIVIDUAL U. S. ANTARCTIC STATIONS WHENEVER DIFFERENT ENVIRONMENTAL, TOPOGRAPHICAL, OR OPERATIONAL CONDITIONS CONTRIBUTED DIVERSE SOLUTIONS FOR THE SAME OR SIMILAR PROBLEMS.

THE OBJECT OF THE COMPILATION IS TO PROVIDE A READY REFERENCE FOR PERSONS CONCERNED WITH THE DESIGN, CONSTRUCTION, MAINTENANCE, AND OPERATION OF EQUIPMENT AND FACILITIES IN THE ANTARCTIC. IT IS RECOGNIZED THAT THE INFORMATION IS HISTORICAL AND PERTAINS TO SPECIFIC OR LIMITED SECTIONS OF THE SOUTH POLAR AREA. HOWEVER, THE SOURCES UTILIZED IN COMPILING THIS REPORT ARE THE ONLY DOCUMENTATIONS OF LARGE-SCALE CONSTRUCTION AND CONTINUING NAVAL SHORE-BASED OPERATIONS IN ANTARCTICA.

FIGURE 1

Environment		Operations	Equipment	Material	Relationships	Applications	Adaptations
Antarctic regions	Beaches		Aircraft				
	Beach sands				Biodeterioration	Coatings as protection	Aggregates, use in pavements
					Corrosion		
Deep Ocean		Construction		Concrete	Deformation	California bearing ratios	
	Evaporation	Deep Ocean operations			Degradation		Buried structures
			(Divers)		Exposure		
			Floating docks		Erosion		Caves, snow
		Harbor operations		Electrical insulation	Fouling		
Marine environment							Filters
					Habitability		Fouling prevention
	Eddy currents	Mooring					
	Harbors	Naval shore activities			Mobility		
	Ice		Ocean structures				
	Marine sediment				Pollution	Protective structures	Packaging
	Marine soil mechanics		Polar structures				
		Transportation		Pontoons			Shockproofing
			Polar transportation equipment		Rusting	Refrigeration	Snow removal
						Snow roads	
Ocean bottom		Storage					
Polar regions			Runways	Quays			
	Sands				Survival	Underwater coatings	
	Sea Ice		Underground structures		Trafficability		Ventilation
	Seawater						
	Soils		Undersnow structures				
	Snowdrifts				Ventilation		
	Underground water		Underwater stations				Water treatment
					Water pollution		
Underwater environment	Water Waves	Water supply		Wharves			Wood preservative

FIGURE 2 SELECTED INDEX SUBJECTS FROM NCEL GUIDE

Documentation Center Technical Abstract Bulletin shows a wide variety of studies bearing upon one or another aspect of the environmental relationship for many Navy, Army, and Air Force laboratories and test sites.

However, there is somehow a loss of specificity between studies and the military documents which either indicate environmental standards for design in general or relate design standards of specific items to environment, and we believe that this may result, at least in the Navy, from the fact that the people who specify requirements are not the people who do the designing.

Military documents. The basic document specifying environmental design conditions is DOD MIL-STD 210A, considered highly inadequate by many design engineers and most scientists. The documents which transmit requirements for new weapons systems components in Navy probably originate in the Fleet, are drawn up in CNO and passed on to Systems Command, whence they go to the appropriate laboratory or to private industry.

In a proposal to the Rome Air Development Center to introduce environmental effects into the process of Weapons Acquisition and Planned Logistic Support, Sykes pointed out the inadequacy of such documents as DOD MIL-STD 210A and suggested the pervasiveness of environmental information by means of a diagram which incorporates the basic design documents of all services (Figure 2).

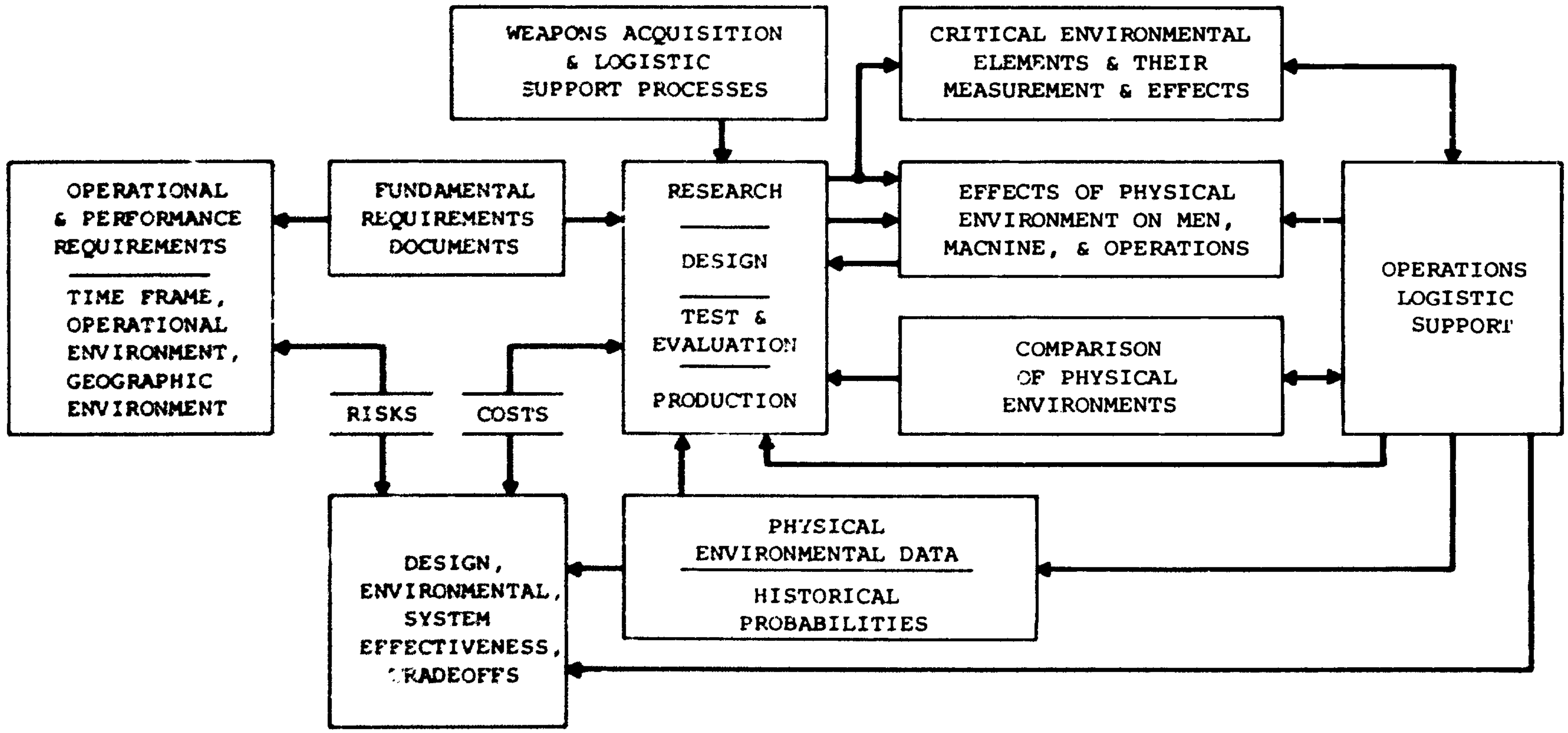


FIGURE 3 THE ROLES OF PHYSICAL ENVIRONMENTAL INFORMATION IN THE WEAPONS ACQUISITION AND LOGISTIC SUPPORT PROCESS

In addition to such formal documents, there are many handbooks, operator's manuals and other instructional materials which contain statements about the environmental limits and capabilities of specific pieces of equipment.

Organizations. In the Air Force, Cambridge Laboratories supply environmental data. In the Army, Natick Earth Sciences Laboratories are responsible for environmental data in the environment-man and environment-materiel (but not weapons systems) relationships. There is no similar office in Navy, although personnel at Naval Weapons Center (Schafer and Kurotori) have been providing a similar service. There is an Environmental Services Office under Joint Chiefs of Staff. In addition, there are numerous "test sites" operated by many agencies of all three services scattered through the United States.

Conclusion. There is recognition of the significance of environmental impact, but the recognition is scattered. It has no focus. There is no systematic approach to the problem, although, as Sykes' diagram suggests, there could be.

Why are Environmental Data Not Handled More Systematically?

There are several contributing reasons to the inadequate treatment of environmental impact, among them man's fatalism about such ambient conditions; the interdisciplinary nature

of ecological studies, and particularly applied ecology of this sort; the complexity of the relationship; and perhaps most important of all, the nature of organizations.

Fatalism. It may be that people who are not concerned about 1,000 deaths a week on United States highways, or the menace of air and water pollution, or the possibility of nuclear war are not going to be very concerned about the increased costs of military operations as a result of environmental ignorance. But one wonders if those costs are really comprehended! In March (1969) a project member reported an interview in which he was told that a big development program, sponsored separately by Navy, Army, Air Force, the Coast Guard, etc., was geared to developing riverine craft for use in Southeast Asia. There was no interfacing. The cost of the total program was some $112 million a year, involving 130 contracts, 60 different kinds of boats, and producing about 1,600 boats a year. Obviously, that expensive environmental effect, for which we were unprepared, has not been investigated properly.

Interdisciplinary nature of ecological studies. Ecology is the science of interaction of systems and their environments. Neither the students of the system nor the students of the environment can bridge the gap alone, except perhaps in rare cases. Naval ecology involves the officers and men who use weapons systems, the engineers and scientists who

design them, and the scientists who provide the basic knowledge on which appropriate design is based. But our methods of organizing activities, of classifying man's pursuit of knowledge, and of rewarding those who are successful militate against men trained to do one thing working with men of unlike backgrounds to do another.

Complexity of the relationship. The most complex area of the relationship stems from the difficulty of abstracting out of a real environmental setting (location) in which there is taking place the wide variety of uses, by people, of the many kinds of materiel and equipment used in even a simple operation, the specific state of elements of the environment that are interacting with specific people, materiel, and equipment in a specified operational state. In other words, given a five man reconnaissance patrol outside of a village near Danang, Vietnam, in July, what are the specific effects of temperature? Of humidity and rainfall? Of surface moisture? Of dense vegetation? How can these effects be stated in terms which will permit the equipment or materiel designer to attempt to offset them? What improvements in performance (accomplishment of operation) are the objectives of design changes?

It is a natural human tendency to back away from analysis of complex interaction processes of this sort and assume that the operational "plan" will take environmental effects into

account and offset them by such strategems as changing the locale of the operation, increasing the magnitude of the effort, etc. But an operational "plan" cannot take these effects into account unless they are known well enough to be stated in some relating and quantifiable fashion. Therefore, environmental intelligence is often no better than the environmental data supplied weapons systems designers.

The nature of organizations. Organizations are typically functional in nature, designed "vertically", in terms of discrete activities. People's capabilities tend also to be classified vertically, according to disciplines or specific jobs. A comprehension of and application of environmental impact requires that designer, tester, and user of a piece of equipment all understand how it will be used, and for what purpose; where it might be used, and what the conditions of environment are there; and how those conditions will affect the use, purpose, and outcome of use of the equipment. In other words, it requires a great deal more interaction than is typical of people in organizations. We suspect, but do not know, that many of the serious problems we face but seem unable to solve today stem from this inelastic characteristic of organizations, this inability of people to work happily between and among disciplines and to interact and communicate with people whose activities are very different.

Conclusion. There seems to be little question that a better understanding of naval ecology could be applied usefully. There is evidence that it would improve the quantity of the contributions now being made by "environmental data suppliers" in DOD. Perhaps an information system is the way to introduce more system and application.

CHAPTER 3

NAVAL ECOLOGY: DEFINING CRITICAL RELATIONSHIPS

The total spectrum of naval personnel and materiel is probably representative of all of the kinds of people and jobs and materials and machines that exist in a modern civilian society. However, the organization of people and things in the Navy is focused on a particular mission, and that is to support United States policy, wherever necessary, by means of the use of weapons. That may appear to be a very broad definition of "weapons". The Navy may send an advisory group to a foreign country to teach its personnel how to use weapons or it may send its corpsmen into a disaster area to provide medical assistance. But for the most part, it will be deploying weapons systems -- ships and planes and missiles with all their supporting paraphernalia -- as a deterrent, or as a counter, to the use of force. So it is convenient to think of any direct (as opposed to supporting) activity in support of foreign policy as involving the use of a weapons system.

The way weapons systems are used, and the choice of weapons systems used, depends upon the nature of [illegible] activity -- in military language, an operation. An operation takes place in a specific environment. Naval operations take place in and on the sea, from sea to shore (coast), ashore, and in the air above both. Therefore naval operations take place in just about every possible earthly combination of environmental influences: deep and shallow seas and rivers, sea and river surfaces, land

surfaces, sea to land surfaces, and all levels of the atmosphere up to very great heights.

An operation is made up of specific combinations of men and materiel performing specific tasks. The influence of environment on both men and materiel will depend to a large extent upon what specific tasks they are performing. Naval ecology is the science of the interactions between environment and men-and-machines in discrete activities.

The kinds of interaction we are most interested in are those in which the environment has some measurable effect on people and materiel, or upon the activities in which people-and-materiel are engaged. For example, people are subject to chilling, overheating, fatigue, and degradation of their ability to see, to move, etc. And many machines are subject to the same kinds of environmental impact. Materiel is subject to gradual degradation (wear, rotting, rusting, decomposition) or immediate failure (breaking, burning, loss). The effects are generally speaking of two kinds. People and materiel are degraded or lost. Activities are inhibited or prevented or enhanced. <u>The most serious effects for naval operations are inhibition or prevention of activities</u>.

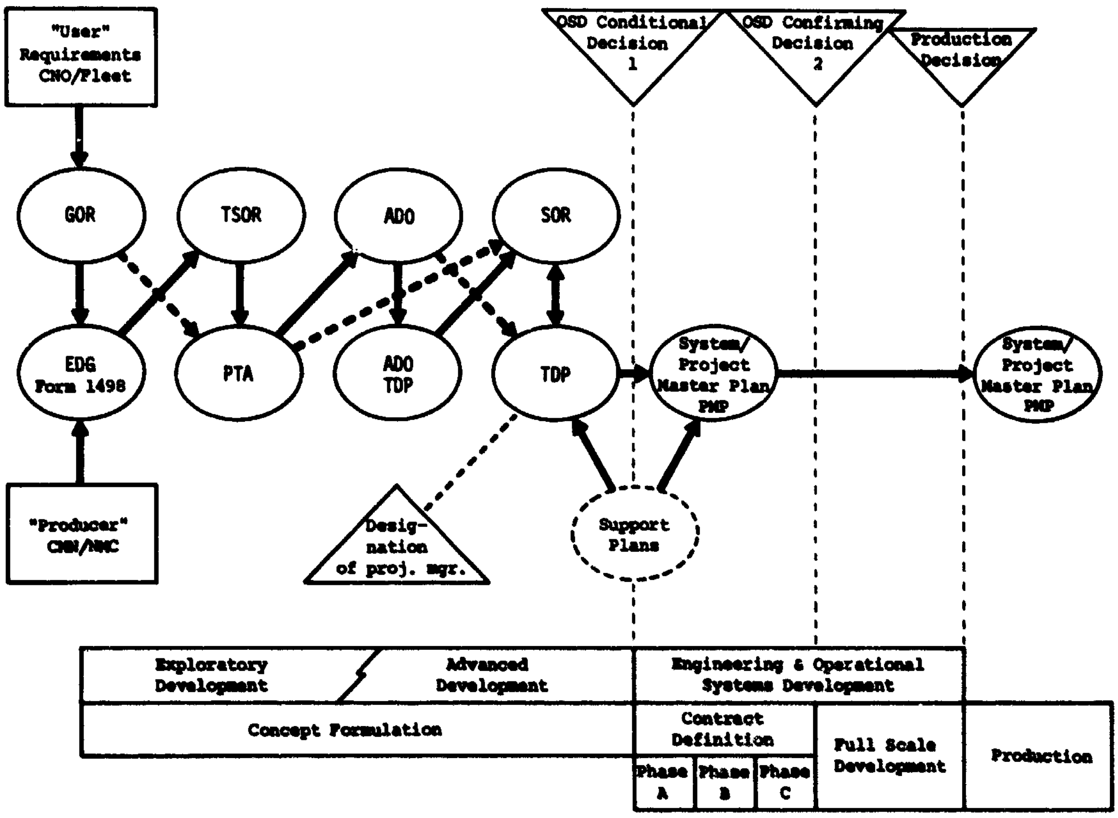
The environment is also affected by the activities of men-and-machines involved in naval operations: cities and supporting services are destroyed, burned, contaminated; ecosystems are disrupted, possibly for generations; people are killed, etc.

The military services of the world, like most of their civilian counterpart activities, have never seriously concerned themselves with this aspect of the activities. But in an era of insurgent and counterinsurgent operations, in which quite literally the prize is not a geographic location but winning the support of civilian populations, a great deal more attention must be given to the effect of naval activities upon the physical, cultural, and social environments.

Role of Weapons Systems

Since the weapons system is basically an organization of men and materiel trained and designed to perform certain tasks, the tangible unit of naval operations affected by environment is the weapons system and its components. The pattern followed by the Navy in its program to develop systems and system components indicates (Figures 4 and 5) that this is indeed a pervasive process, based on national policy, involving fleet and CNO recommendations, and involving not only laboratories and industry but ONR as well.

Design criteria. A review of Navy documents involved in this process (GOR's, SOR's, etc.) by project personnel, and of such documents applicable to Marine Corps operations by Geography Programs personnel, revealed a tremendous variation with respect to perception of the significance of



EDG Exploratory Development Goals
GOR General Operational Requirement
SOR Specific Operational Requirements
TDP Technical Development Plan
TSOR Tentative Specific Operational Requirements
PTA Proposed Technical Approach
ADO Advanced Development Objectives
Form 1498 Summary of Exploratory Development

Classic route if each step was taken in sequence (this is not always the pattern).

Frequently taken short cuts.

FIGURE 4 SYSTEMS PLANNING

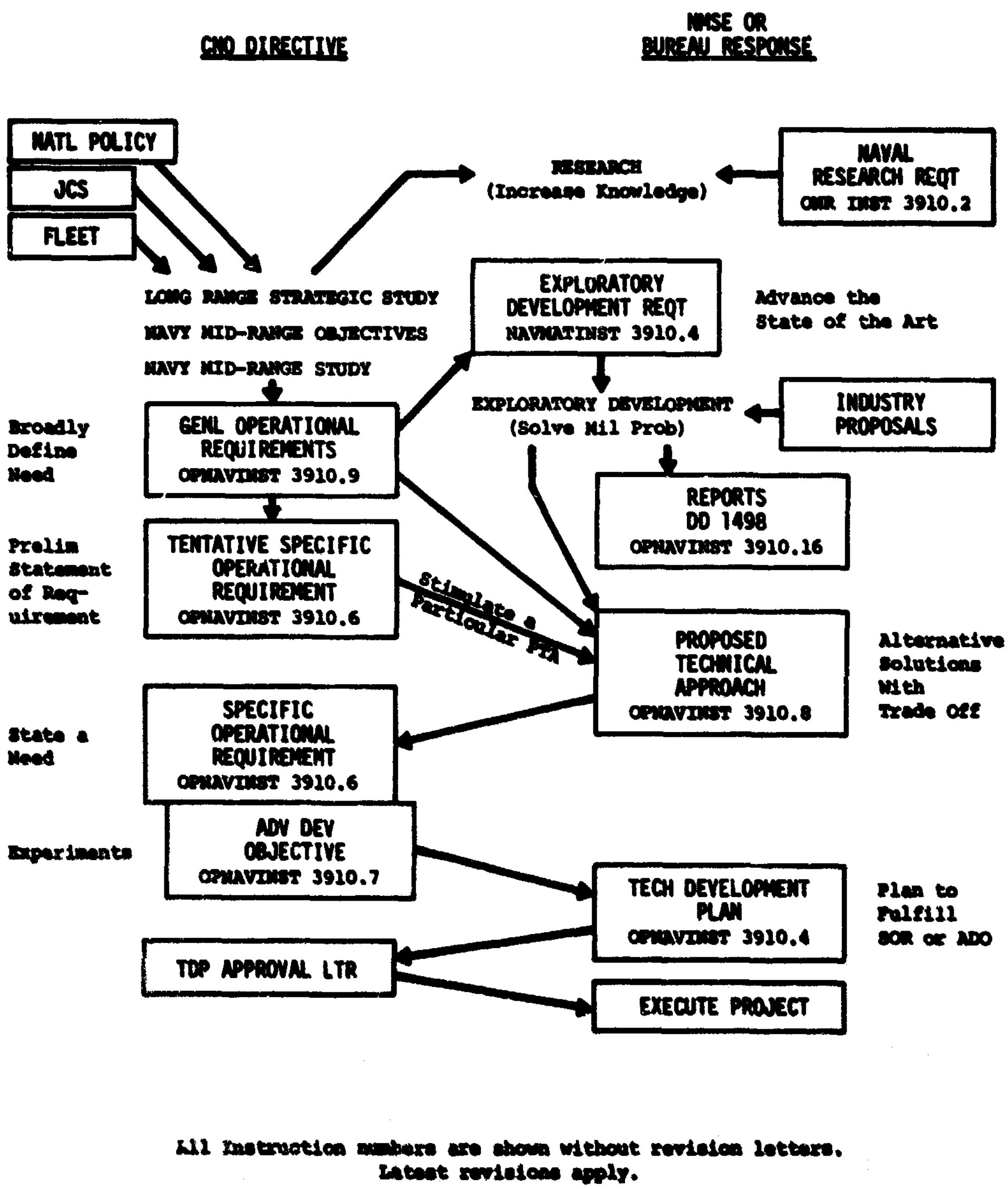


FIGURE 5 DOCUMENTATION OF REQUIREMENTS FOR DEVELOPMENT EFFORT

environmental influence -- in these instances, of course, in terms of design criteria. Some documents specified in considerable detail conditions of the environment in which a weapons system component must operate (e.g., water depths of 2 feet, 95°F. at sea level, 10° slopes, etc.), while others covered environment in such terms as "all weather capability", "temperatures from -65°F - +125°F.", etc.

Laboratories. However, the story was a very different one in the laboratories. Interviews with laboratory personnel (for list of offices visited, see Appendix I) and laboratory reports frequently indicated a real preoccupation with conditions of the environment in which a particular device would operate properly. Although this may be an overgeneralization, it appeared to us that requirements documents (GOR's, etc.) tended to overstate it somewhat, at least in terms of the number of environmental parameters laboratory engineers and scientists said they had to know about. Of course, we did not visit *all* laboratories, or all of the other centers and stations at which testing and evaluation and environmental studies were being carried out, but we believe the difference reflects the fact that the engineering concern is much broader than the operational concern: it includes long term durability and cost-effectiveness, whereas the operational concern is with short term optimal functioning. Both are important and are part of naval ecology, but the significance relates to the particular naval function, as we hope to show.

Laboratory reports, handbooks, technical manuals, operating manuals. We were not able to survey all of the literature directly concerned with the design, test and evaluation, development, transportation, use, and storage of naval materiel -- all of which we assume to be weapons systems "components", since all are designed to support some activity relating to the overall Navy mission. However, we have looked at enough bibliographies of reports of studies made by, or supported by, naval activities of various sorts to know that the environmental effect on materiel is very often a major consideration, as indicated in the previous chapter. This is apparently not so often the case in technical manuals, handbooks, and operating manuals, in all of which the major effort is to describe how a component works, what all of the gadgets mean, and what some of the prominent operating problems will be.

Range of impact of environment on weapons systems. In general, environmental relationships are stated in terms of design for *operation*, which is of course of major importance for the development process. Some, but relatively few, consider environment in relation to *transportation*, *storage*, or *maintenance* of the component.

Present State of Knowledge and Application

At present, knowledge and application of the principles of naval ecology constitute an incomplete system. The importance assigned to environmental impact on a given weapons

system component depends on the individual design engineer; the importance assigned to impact of environment on a specific operation depends upon the experience of the officers in charge; the ability to avoid environmental pitfalls and use environment positively when operating a specific component depends upon the experience and training of the operator.

There are many specific assessments of the design and operation of weapons system components. There are many specific assessments of operations. And there are many careful studies of various environments. But for the large part these have not been put together to form a consistent system of knowledge which will enable a planner or commander to optimize an operation in support of a mission in a particular environment.

We believe it is possible to begin to structure such a system upon the basis of what is already known. As we see it, many existing pieces of information basic to the system have not been put together.

To put them together one needs some sort of organizing "model" of the system.

To make them effective, this model must be the heart of a functioning information system.

A Model of Naval Ecology

A very general graphic representation of a naval ecological system is attempted (Figure 6). This not only shows some basic operations-weapons systems-environment relationships

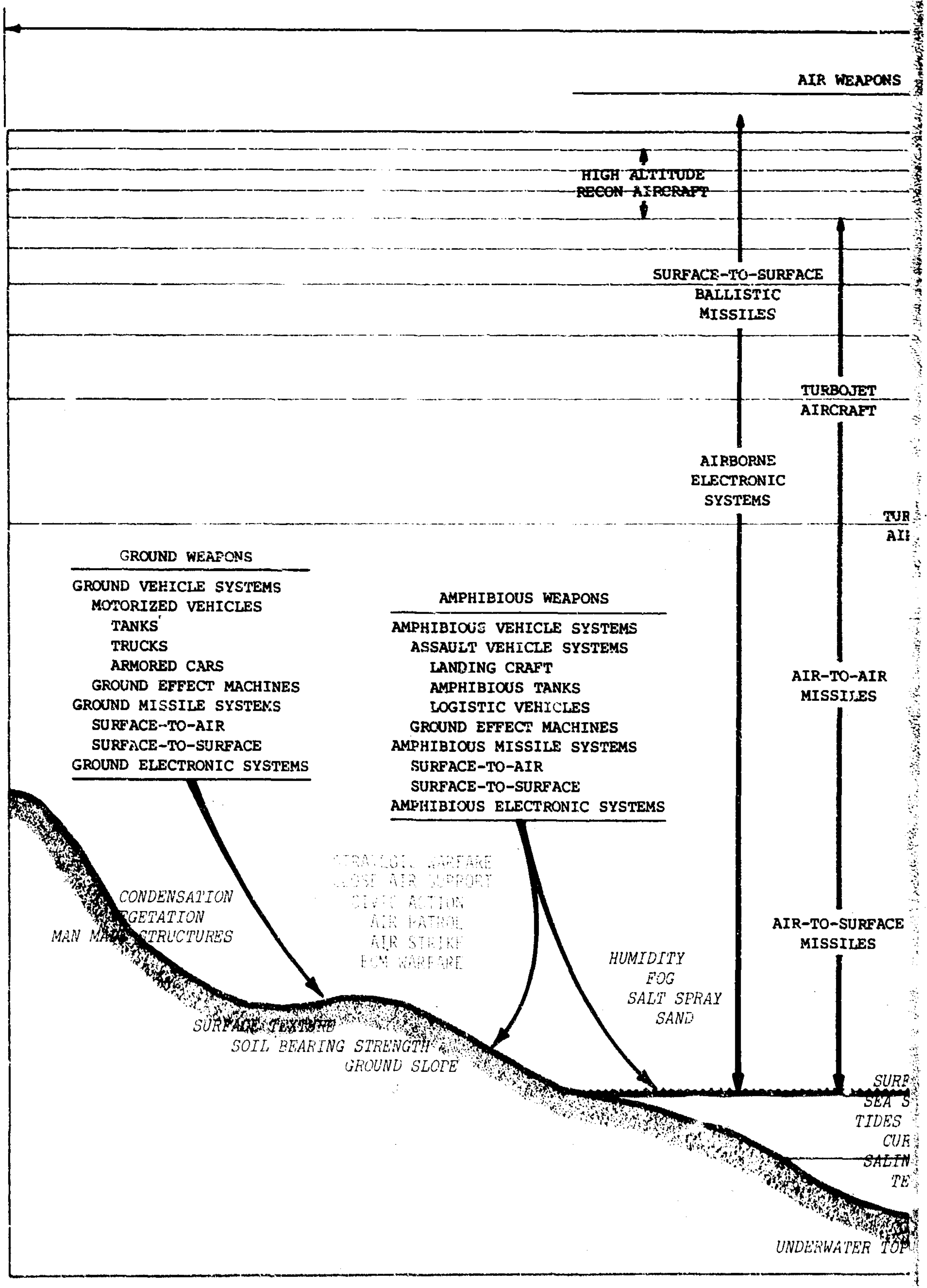
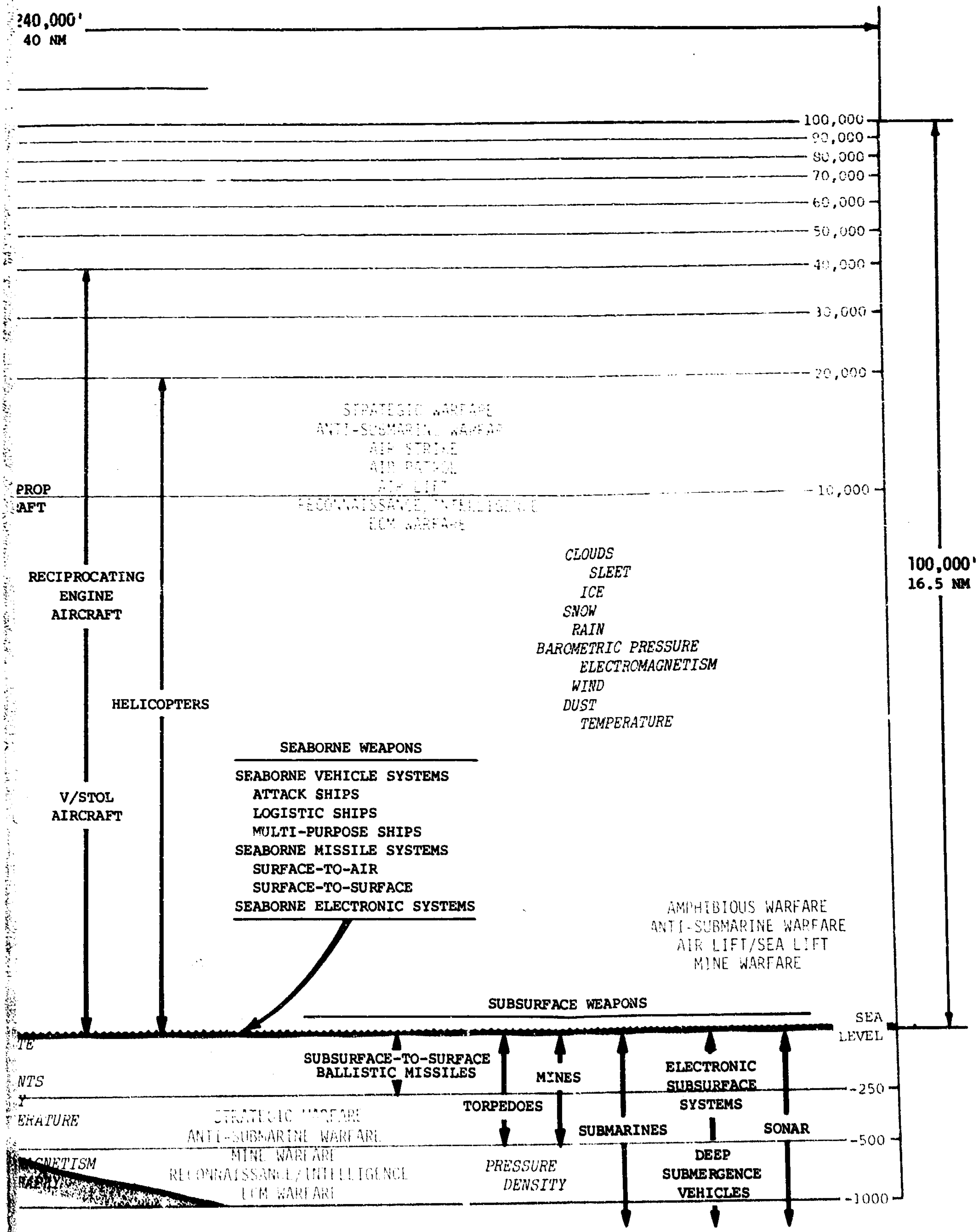

AIR WEAPONS
HIGH ALTITUDE
RECON AIRCRAFT
SURFACE-TO-SURFACE
BALLISTIC
MISSILES
TURBOJET
AIRCRAFT
AIRBORNE
ELECTRONIC
SYSTEMS
GROUND WEAPONS
GROUND VEHICLE SYSTEMS
MOTORIZED VEHICLES
TANKS
TRUCKS
ARMORED CARS
GROUND EFFECT MACHINES
GROUND MISSILE SYSTEMS
SURFACE-TO-AIR
SURFACE-TO-SURFACE
GROUND ELECTRONIC SYSTEMS
AMPHIBIOUS WEAPONS
AMPHIBIOUS VEHICLE SYSTEMS
ASSAULT VEHICLE SYSTEMS
LANDING CRAFT
AMPHIBIOUS TANKS
LOGISTIC VEHICLES
GROUND EFFECT MACHINES
AMPHIBIOUS MISSILE SYSTEMS
SURFACE-TO-AIR
SURFACE-TO-SURFACE
AMPHIBIOUS ELECTRONIC SYSTEMS
AIR-TO-AIR
MISSILES
AIR-TO-SURFACE
MISSILES
CONDENSATION
AIR PATROL
AIR STRIKE
HUMIDITY
FOG
SALT SPRAY
SAND
SOIL BEARING STRENGTH
GROUND SLOPE
TIDES
UNDERWATER

FIGURE 6 NA

H



AL ECOLOGY OF COASTS

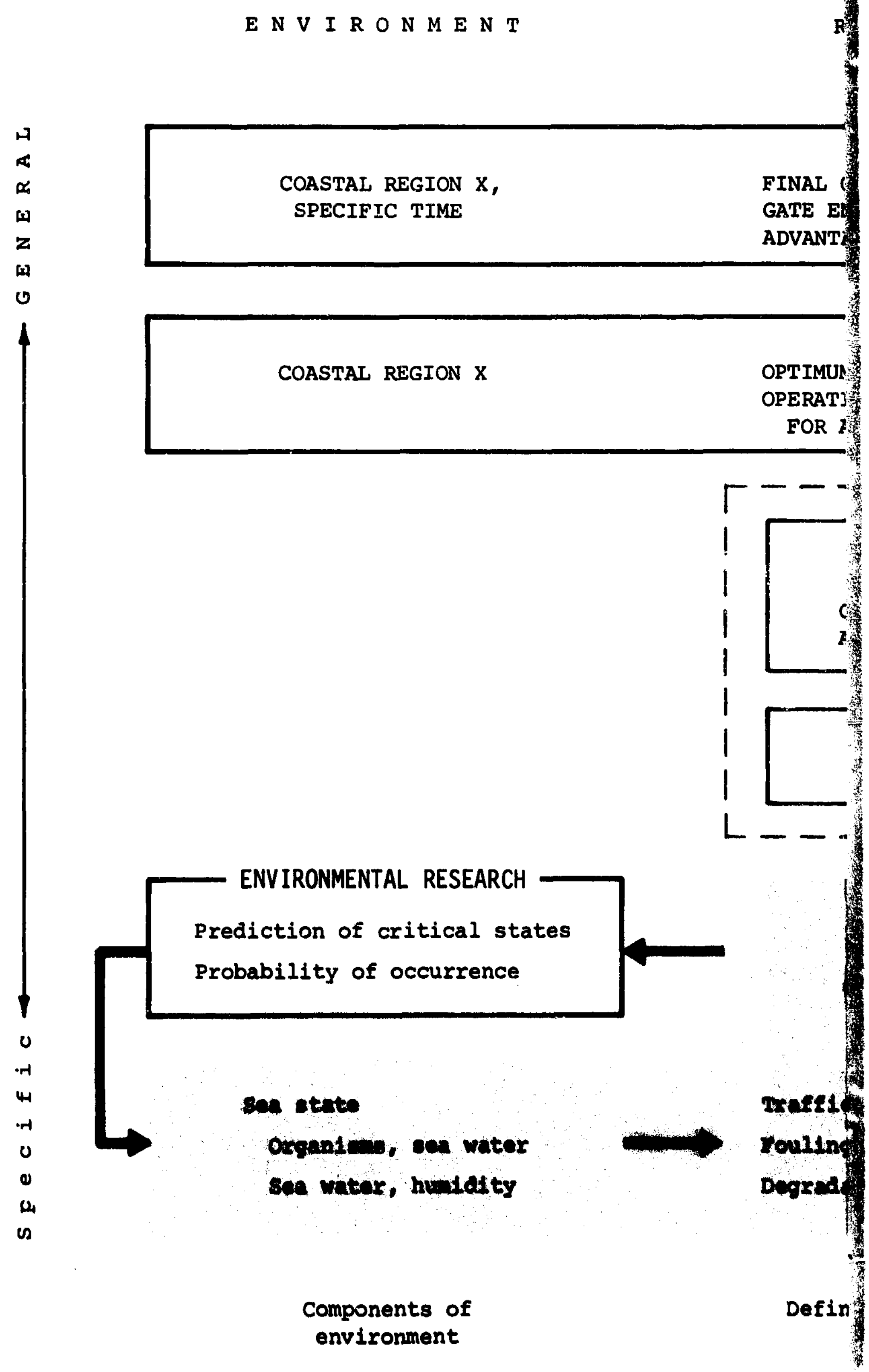
(e.g., which operations are carried out where with which weapons systems), but also some of the environmental constraints upon the systems (e.g., heights to which various craft can safely submerge). In other words, the general range of <u>things</u>, <u>activities</u>, and <u>ambience</u> is illustrated. The problem is to reduce this general picture to some positive statements about capabilities and limitations, go-no go situations, etc.

<u>Structure of the relationship</u>. The idea behind structuring this relationship is simplicity itself. Just as the total amount of "business" for one day in a large department store is the sum of many small and large transactions of all kinds, so the total impact of weather and sea state and coastal topography on an amphibious operation is the sum of many small and large effects of states of the environment upon men and materiel involved in many kinds of activities. To predict or simply keep track of total business or total impact one needs some sort of accounting system -- an accounting system based upon an understanding of how the small events add up to larger ones which add up to totals. Some banks understand these relationships well enough, for example, to be able to get reliably accurate figures on the day's business by sampling the transactions instead of accounting for all of them. This will obviously be necessary in certain aspects of the use of environmental data -- especially in strategic planning and in operations; on the other hand, development will probably

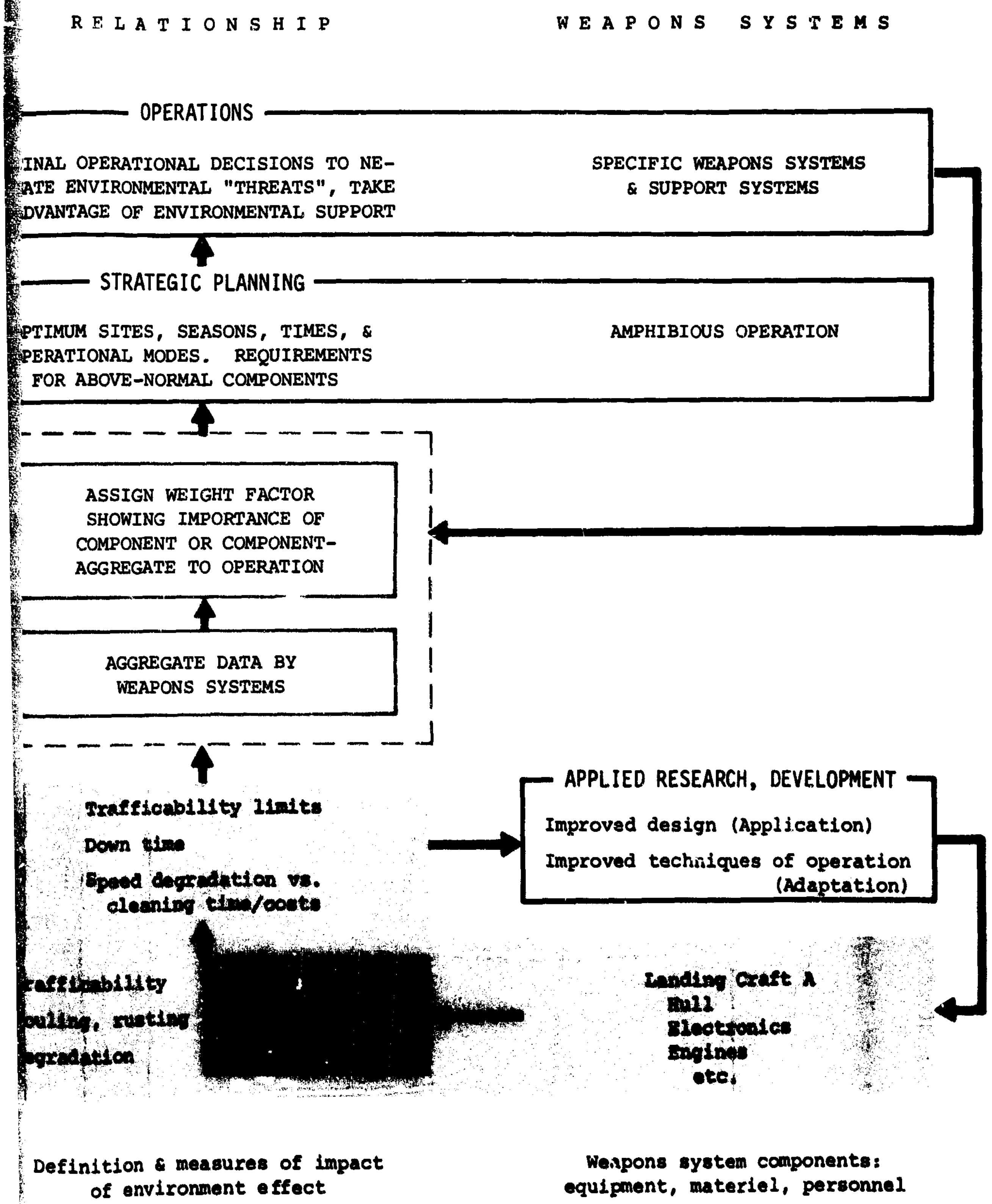
want to consider all known relationships, and research will be necessary to support both the knowledge of relationships and the bases for sampling.

One assumption behind the structure suggested is that any small effect can be traced to the part it plays in a larger effect. This is a reasonably certain assumption, because all of the categories of the relationship are aggregatable and the effects are largely measurable. The array of index subjects from the NCEL GUIDE in the preceding chapter (Figure 2) suggests that development investigations regularly examine the relationship at several levels of aggregation: structures are designed for the marine environment, but at the same time the biodeterioration, corrosion, fouling, etc., of various kinds of materiel and equipment are studied with respect to specific aspects of that environment.

A graphic portrayal of the model concept (Figure 7) shows how all categories and their ecological relationships within specifically defined operations are discrete with respect to naval function. One would expect the normal laboratory investigation to be at the most specific level of materiel and element of environment, and usually either this is the case or such studies have been made and are basic to designs of such collective materiel designations as "structures"


E N V I R O N M E N T
COASTAL REGION X,
SPECIFIC TIME
FINAL (
GATE E
ADVANTA
COASTAL REGION X
OPTIMUM
OPERATI
FOR A
G E N E R A L
S p e c i f i c
ENVIRONMENTAL RESEARCH
Prediction of critical states
Probability of occurrence
Sea state
Organisms, sea water
Sea water, humidity
Traffic
Fouling
Degrad
Components of
environment
Defin

FIG



B

FIGURE 7 NAVAL ECOLOGY

or "aircraft". It is quite normal to apply all of the known principles of environmental relationship of materials, wing conformation, structural strength, etc., to design.

Explanation of model. The distinction between the significance of environmental impact to research and development, on the one hand, and strategic planning and operations, on the other, is apparent. Research is concerned with unknowns in the environment; applied research is concerned with the unknowns in the environment-weapons systems relationship; and development is application of principles of relationships to improved weapons system design or adaptation to environmental stress by means of new use techniques. (The distinction between research and development, which we will elaborate somewhat in the following chapter, becomes quite understandable in this context: applied research and development clearly take their cues from requirements for new or modified weapons systems, whereas research tends to be generated by ignorance about the environment. To give such research naval relevance it is necessary to conduct it in those areas of ignorance which have the greatest impact on use of present and proposed weapons systems.)

In both activities all ranges of impact, from minor to major, are considered: that is to say, the optimum functioning of all equipment and materiel is important. There is therefore no relationship -- no aspect of naval ecology -- that is unimportant to these two basic naval functions.

In <u>strategic planning</u> and <u>operations</u> the significance narrows down rapidly to weapons system <u>critical</u> to an operation, and to the importance of environmental impact on their successful functioning.

To illustrate the difference with examples, corroded cables may affect an operation adversely when they do not function properly. But that is not the commander's concern: design features and maintenance procedures are supposed to preclude such malfunctions. However, design and maintenance often provide adaptation only up to certain limits of environmental impact, and the commander must know for critical components -- such as landing craft in an amphibious operation -- what those limits are and the extent to which such conditions will inhibit or stop landing craft. More, he must know what that "extent" means in terms of success of the overall operation.

This means that the universe of environmental-ecological-engineering knowledge which is so necessary at the research and development levels must be focused for practical use at strategic planning and operations levels. The focus is achieved by two analytical procedures, shown in the center of our model:

(1) impact data must be <u>aggregated</u> in terms of weapons systems, giving the commander some quantified idea, for example, of how many amphibious craft will not reach shore in sea state X, and

(2) every component must be assigned a weighting factor indicating its importance in the overall achievement of mission; for example, what are the really <u>critical</u> weapons systems components in an amphibious operation? To know what effect sea state X will have on mission success, he must know how large a factor landing craft will play in that particular operation.

<u>Building the Applied Science, Naval Ecology</u>

The building blocks of this applied science are at the level of greatest specificity in the model. For very specific engineering and design purposes many of the relationships at this level have been examined and are being examined, and there is a wealth of reports in which highly [illegible] relationships are examined or inferred, in which [illegible]nts for new environmental data are indicated, in whi[illegible] of environmental impact is implied, etc.

One of the basic steps in making these widely scattered kinds of relevant information useful is to pull together what is known, what is inferred and implied, and what is not known. It will be in a sense a pioneering effort to demonstrate: (a) how much is known about naval ecology, and (b) how important this information is when it is put together in a coherent system of principles of relationships. As this is accomplished, the results should be transmitted by some

media, probably in the form of reports, to both ONR and the naval laboratories, for obvious reasons in both cases.

The two processes which link these scientific and engineering data to planning and management, and which in effect select out management applications, are data aggregation by weapons systems and systems analysis of operations-and-weapons systems for the purpose of assigning weight factors to critical weapons systems components in given operations. The first is a logical development of systematizing naval ecological information. The second is probably only worth doing if an information system for management use is going to be developed, in which case it would be a function of whatever agency sponsored development of the information system.

CHAPTER 4

THE DISTINCTION BETWEEN RESEARCH AND DEVELOPMENT

There are such fine shadings of difference between basic and applied research, and between applied research and development, that it is often very difficult to know into which category a particular project fits. Nonetheless, the Navy makes the distinction. Funds categorized "research" are administered in ONR, while funds labeled "development" and "advanced development" are administered in the Materiel Command. Excepting the Naval Research Laboratory, most development and advanced development are carried out in naval laboratories, which also may do some relevant basic research, frequently with ONR funds. Both ONR and the laboratories rely heavily on people and organizations "outside" the Navy in their programs: ONR on universities, the laboratories on industry.

It is perfectly obvious to everyone -- including everyone in Navy -- that there should be the utmost coordination among these three classes of studies and investigations supported by a single organization. There can be no question that anything supported by Navy funds ought to support the overall Navy mission in some discernible fashion, with the general philosophy in mind that whatever helps Navy perform effectively is also in the national interest. In fact, the

laboratories tend to be product directed, while in ONR it is the responsibility of program directors to assure mission relevance.

That there is in fact not very much coordination is the most natural thing in this modern technological world, as noted before. Not to belabor the point, may we just say that coordination among elements of an organization is seldom perceived as a path to personal or organizational achievement and glory. On the contrary, competition is appropriate. In brief, in ONR the payoff is in basic research -- new knowledge; in the laboratories, the payoff is in development of new materials, new equipments, new weapons systems.

But this is not the only facet of competition. For the laboratories themselves are functionally distinct, oriented toward different aspects of Navy hardware and operations, and geographically separate. Among other things this means that although there are officially 12 naval laboratories, one of these (NRL) is attached to the Chief of Naval Research, and the other 11 do not by any means represent the Navy's only resources for development activities. There are many "centers" and "stations" and "sites" which are also involved in similar activities. The reason for this, of course, is that there are problems to solve, and people will attempt to solve them according to their own particular capabilities

and interests. So an organization chart rarely provides an accurate picture of what is going on at a particular installation. Besides, American industry plays a large role in development for Navy.

If we can accept the fact that large organizations are probably no better organized than we are as individuals in our daily lives, then it is possible to understand why it is difficult, if not impossible, to coordinate fully for naval relevance the wide variety of organizational units located all over the United States, some within Navy but many outside, which are spending the money labeled "research", "development", or "advanced development". While it is human nature to attempt to fit large groups of people into discrete functional categories and assume that people so grouped are performing the specified function, it is common knowledge that things do not work out this way. Scientists inclined toward application are going to incline toward application whatever their assigned tasks, and engineers interested in basic research are going to find ways to spend their time on basic research.

Unfortunately, this creates some problems:

(1) The organization of environmental data collection, for example, obviously is not optimized by assigning the oceans to one agency and the atmosphere to another. There is no universal system of data design for either; information

format is specified by need, and it is hard for a collection agency to be totally responsive to a variety of needs, even if communication among agencies were good, which it isn't. What happens very often is that the functional agency with a need either uses inappropriate data, or attempts to extrapolate and translate, or collects its own, or does without. Meanwhile, the collection agency goes merrily ahead collecting all kinds of data which are not used by anyone.

(2) There has been little research on the interaction of environment and military operations (as opposed to a great deal on the interaction of environment and metal corrosion, for example). The reason is that no one has the responsibility for knowing about this except the commander of an operation. (The only special facets of operations singled out for attention are intelligence, and much more recently, logistics.) The commander learns the rudiments of environmental impact: weather, something about terrain, sea state, surfs and beaches. But this covers such a wide variety of complex situations -- this naval ecology -- that no commander can possibly give the time and effort to organize a special investigation. It is still largely an art instead of a science.

(3) There must be enormous duplication of effort. I have referred earlier to the wide variety of riverine craft

being produced by a number of different branches of service, possibly for slightly different uses, but all for the rivers of the Vietnam delta area.

Conclusions. The impasses created when vertically-structured organizations are unable to solve inter- and intraorganizational problems -- problems which literally require a "team" approach to solution -- exist throughout the modern world and are not going to be overcome here. But it does appear that providing and soliciting information may be an integrating activity that will help increase the amounts of cross-organizational communication and coordination without endangering the precepts and validity of the organizations and individuals involved. I think the concept here is that there is more power to be exercised in distributing information than in withholding information, a concept that most managers and leaders apparently do not accept.

CHAPTER 5

THE KEY ROLE OF A COASTAL INFORMATION SYSTEM

Our conclusions are that environmental impact on naval operations is significant and that much more is known about such impact than is applied. Present naval organization is one of the reasons that ecological data have not been systematized and principles of environmental impact applied in an integrated fashion to all naval functions. This is quite understandable, and we do not suggest reorganization. Instead, we believe that creation of a coastal information system would provide impetus for increased sophistication in the development and use of environmental impact data -- and would at the same time help integrate naval functions which now tend to be separated by organizational gulfs.

If this appears to be a case of rationalizing one's original goals, let us point out that what we originally thought to be our objective is also a way of introducing new ideas without drastically altering the present naval *modus operandi*. In other words, the coastal information system is now not just an end in itself, but a way of achieving a number of related objectives, by no means the least of which is an integrating communication system among the organizations supporting the four basic naval functions. One has only to look at the impact of accounting systems on the patterns and

personalities of different businesses to realize the significance of the <u>form given to information</u>: cost accounting systems which originated in Germany during World War II are credited with the incredibly efficient German use of raw materials, and the same systems apparently were basically responsible for directing the post war Ford Motor company toward profits instead of losses. The term "system" is significant here, because system thinking is integrating thinking.

The heart of any system is the transformation process -- the ways in which inputs are transformed to outputs -- because the outputs are no longer data to be translated according to the decision-maker's experience: they are, in fact, statements of philosophy and interpretation which help make the decisions. In effect, the transformation process <u>is</u> the system, and whoever controls this process can indeed exercise a great deal of influence, not by withholding information, but rather by marshalling it -- which means giving functional activities the pieces of the integrated information output they require. When we could not make real headway in determining requirements -- and thereby specifying outputs -- we investigated the transformation process to see how environmental data were being managed within Navy.

The Transformation Process: Coastal Information

Our first attempt at structuring this process was reported previously (October 1968). We postulated that the transformation processes were defined by such terms as selecting, filtering, monitoring, translating, factoring, relating, summarizing; that they represented key relationships within the system and with other systems; and that these relationships could be "located" at three interfaces. (The term "interface" tends to be gobbledegook, and for this we apologize.) What we meant was that at three "locations" in the system the characteristics of competing, or at least different, functions had to be resolved in Navy's favor. One of these was the point at which coastal data entered the Navy system from outside sources, and here all relationships other than the environment/military operation relationship were filtered out. Another was the point at which areas of the world unlikely to have any significance to Navy in the foreseeable future were screened out. A third was the internal Navy bias which translates most naval requirements in terms of weapons systems.

As we have defined them, the interfaces are conceptual. But they should exist in a functional sense if not in an institutional sense: that is to say, someone, somewhere in Navy should be involved with these interface functions, because coastal information does in fact move into and through the system.

In terms of these concepts we drew up the Coastal Data Flow Information System (Figure 8). On the basis of this we suggested in our first report that the second year's effort be an examination of the real system as compared with our conceptual system:

> The purpose in doing this is to be able to make some generalizations about the transformation processes presently at work and to what extent they appear to be equivalent to requirements. It is a reasonable assumption that the points at which the "real" system and the "ideal" system do not match are points about which some management decisions can be made. (p.59)

The "Real" System

The "real" system we took to be those information flows which supported the entire range of weapons systems activities, from determination of requirements to design and exploratory development, from test and evaluation to advanced development, from transport and storage to use and maintenance. In fact, our contacts with the laboratories indicated that the weapons system orientation was real, and the approach to weapons systems procurement in Navy is in every sense a system: the various aspects of the system are charted in Figures 4 and 5. What these charts do not indicate is the input of environmental data required for such a process. A comparison with the process chart drawn by Sykes (Figure 3) shows how many possible omissions of environmental data occur.

Although the documents themselves -- the GOR's and their corresponding SOR's and TSOR's, and the feedback documents,

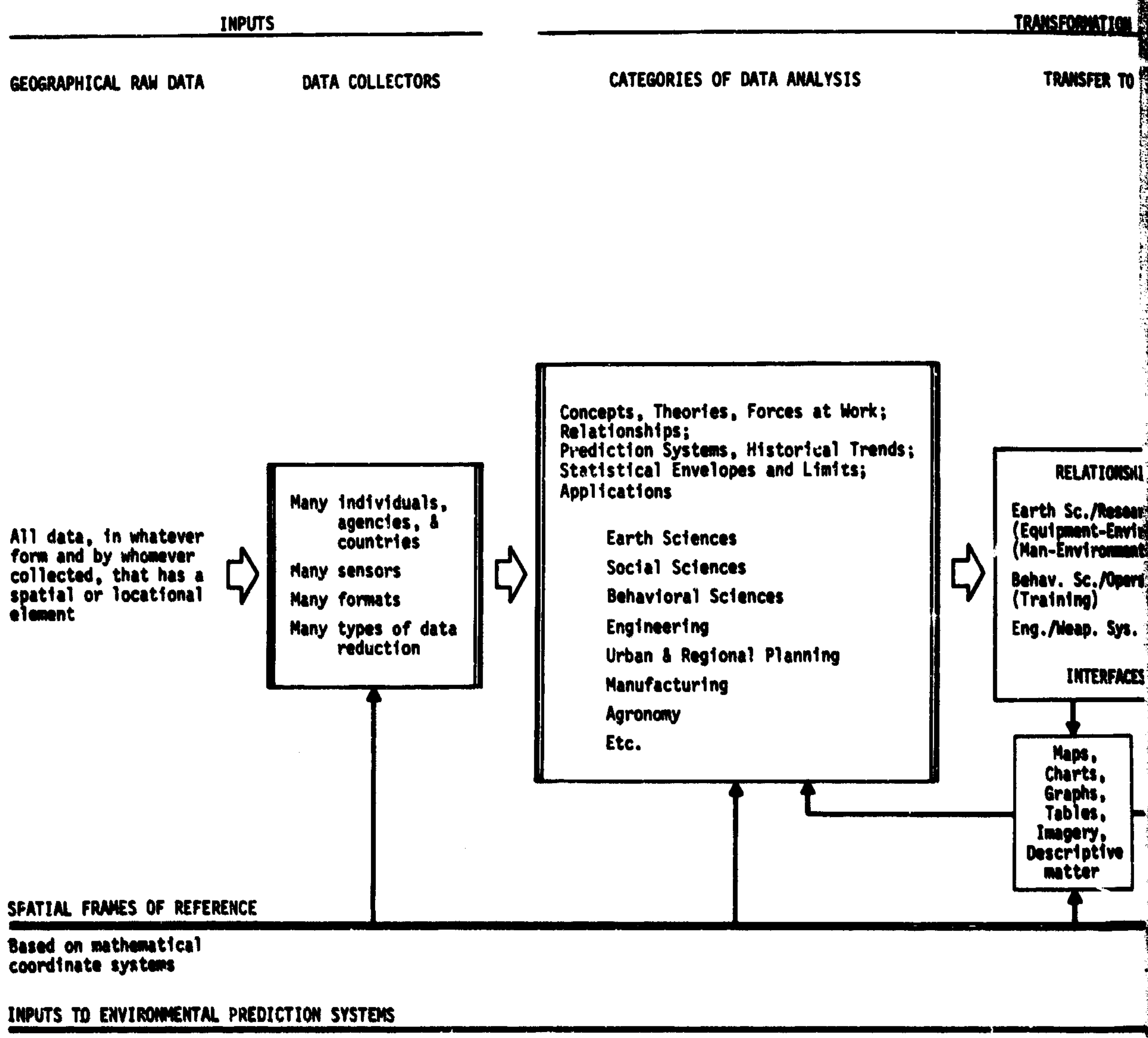
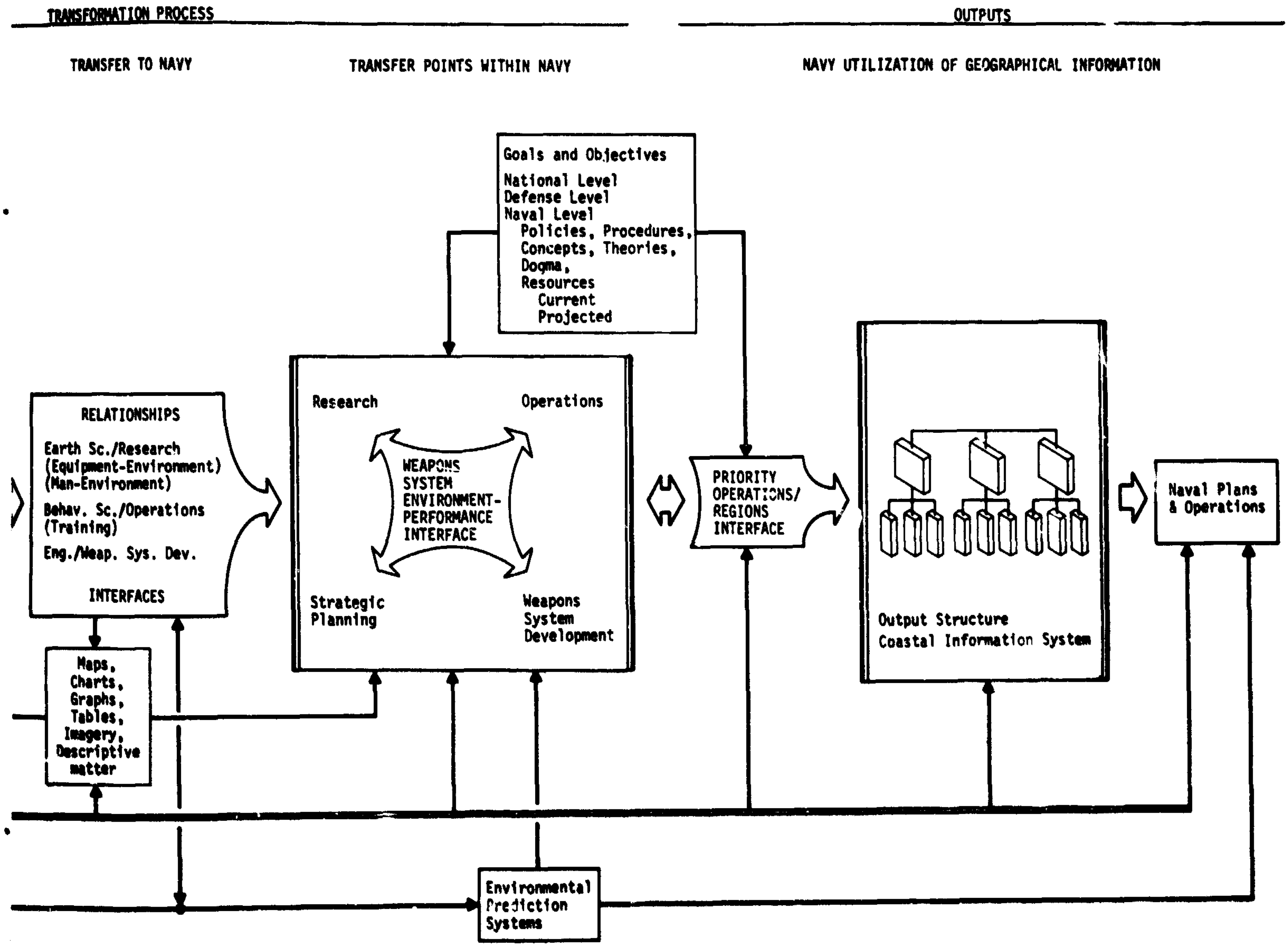


FIGURE 8 COASTAL DA



COASTAL DATA FLOW INFORMATION SYSTEM

TDP's, EDP's and PTA's, contain varying amounts of environmental "requirements", and there is a general framework of military environmental standards, our interviews with laboratory personnel clearly indicated that environmental data are much more prevalent in the process than indicated by the documents themselves.

We believe that the role of coastal (environmental) data is much more fully portrayed in Figure 9. Environmental data are supplied to the fleet and to CNO from a variety of intelligence and environmental data disseminating sources. These sources are also used by the laboratories, which can draw upon ONR as well as many outside agencies for environmental data they need; and many laboratories collect data informally themselves. Industry probably has about the same sources as do the laboratories.

Evaluation. This is a system with many hiatuses, largely because it is a system only informally -- because we have chosen to regard it as a system. Weapons systems procurement is indeed a system, and a formal one. But coastal information as a supporting system for all naval functions in support not only of procurement (design and development), but also use, transportation, storage, and maintenance of weapons systems does not exist. If there were a formal system, it would have

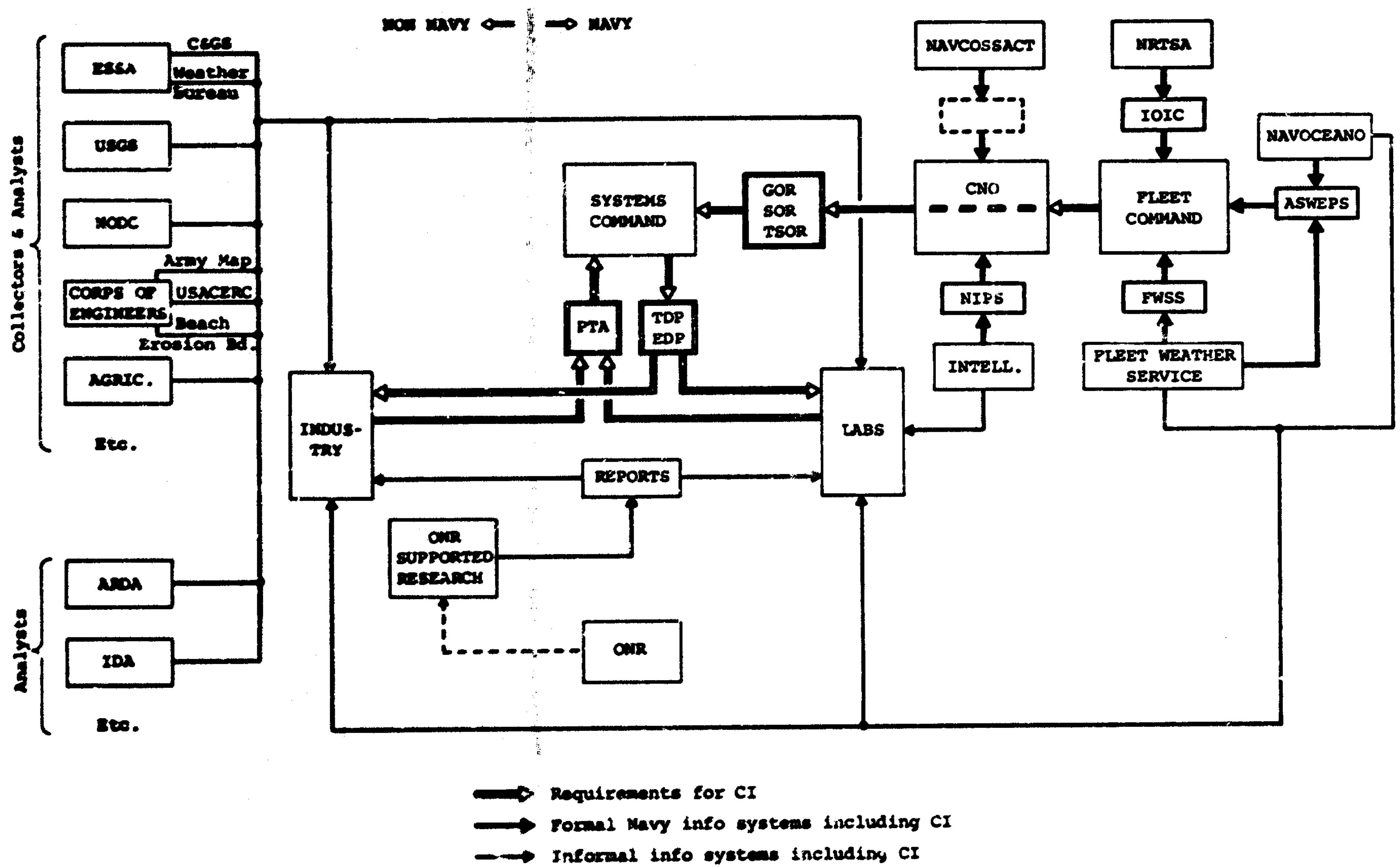


FIGURE 9 THE ROLE OF COASTAL INFORMATION IN WEAPONS SYSTEM DEVELOPMENT

these characteristics which are now missing:

(1) Environmental data would be translated into immediately applicable information outputs for each of the four functions: as it is, there is very little difference between data inputs and data outputs, and there is no environmental data system designed to meet the needs of either the research function or the development function;

(2) There would be feedback of operational data from industry and laboratories to CNO and Fleet Command: instead, numerous reports are generated which are not even circulated among laboratories;

(3) There would be feedback of scientific data from research to industry and laboratories: instead, reports are generated which are available on the same basis as laboratory (and industry) reports.

Notice that these points relate only to what we have called the weapons systems interface -- in other words, the internal-to-Navy process of translating and marshalling information in support of the four basic functions. The priorities interface probably exists in some fashion: there was no point in investigating what is probably a highly classified activity until an actual information system was put into operation; it is enough to specify the requirements for the activity. The relationships interface consists of a hodgepodge of contacts with information sources outside

Theoretical System: Preliminary Design

Navy; it can be defined to some extent when the system is designed, but it will probably continue to be a hodgepodge because environment-military relationships are not very exclusive.

A Theoretical System

Examination of the present system and what was missing from it, when coupled with the investigation of the development potential of naval ecology, convinced us that it was now possible to specify in some detail the nature of a theoretical coastal information system responsive to naval requirements (Figure 10). The following are our specifications:

INPUTS

(1) Relationships data. Incorporating the basic concepts of the model of naval ecology, the heart of system inputs is a data bank which contains all available information on the relationships involving components of environment with components of weapons systems -- i.e., all materiel, equipment and personnel in all possible activities subsumed under design, test, evaluation, etc. Inputs to this data bank are categorized in all possible ways, so that relationships data can be retrieved, grouped, and analyzed from the varying points of view of elements or aggregates of environment, location, relationship (kind of effect), class of thing or person, category of activity, stage in weapons systems process, etc. (Our exercise with three-dimensional matrices shows this is possible.) These data come from any possible source, but primarily, one

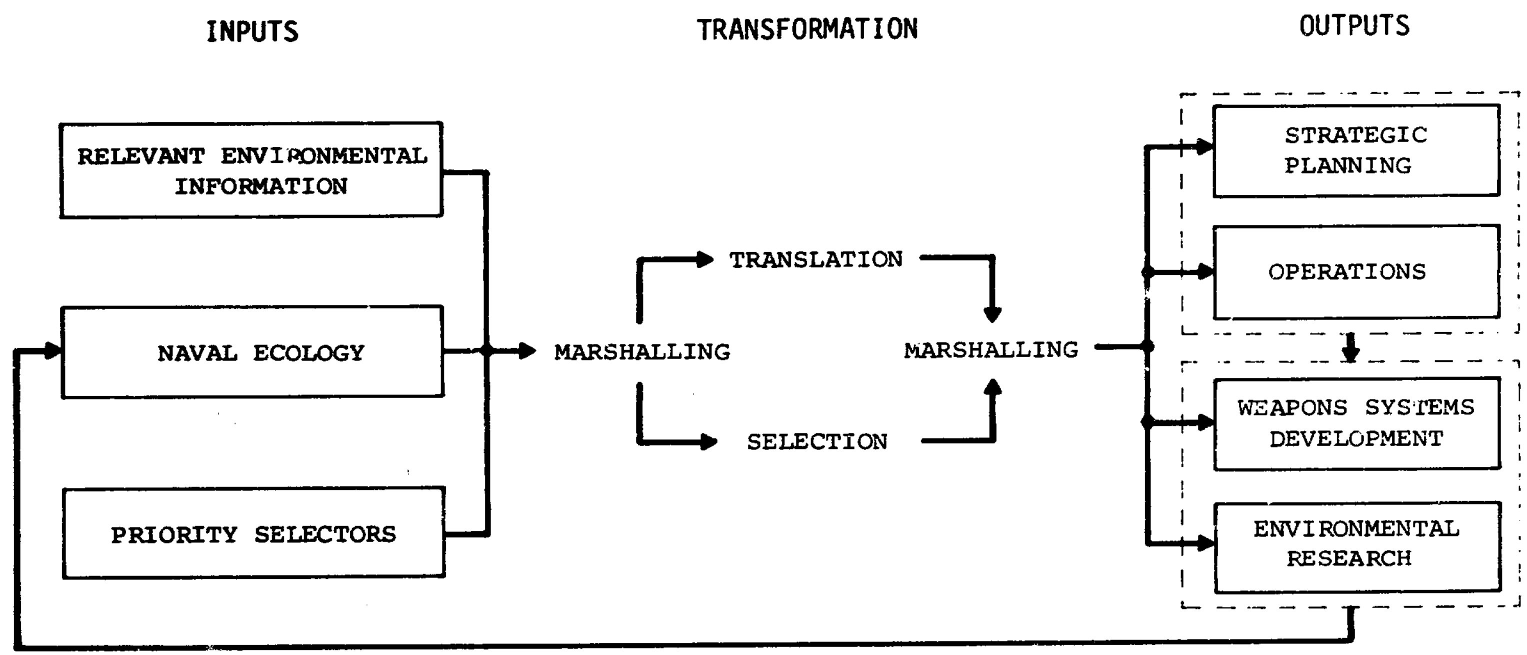


FIGURE 10 DESCRIPTION OF A COASTAL INFORMATION SYSTEM

would think, from military laboratories and from industry. There may be several classes of such relationships information, but at the very least there should be two: (a) relationships which are in some sense "preliminary" or "exploratory" or even "hypothetical", and (b) relationships observed often enough to be stated as principles of naval ecology. The latter are the most useful, of course; the former indicate a need for further investigation, perhaps; and an absence of either in significant areas of developing weapons systems components is a signal for activity in development or research or both.

Information, or lack of information, in the data bank should be immediately available on request to ONR, all naval laboratories and development centers of whatever type, and industry supporting naval weapons systems development.

(2) Environmental data. The data bank is the basic input to the system: in terms of its stated relationships environmental inputs are generated. A relationship will specify environmental conditions: this generates a request for data, and it should be known whether the necessary data exist and if so in what format, coverage, etc. If the data required are such that statistical means or probabilities are insufficient, sources of predictions should be indicated. If data are in any sense unavailable, this information should be stored. Relationships firm enough to be stated as principles

should be backed up with all available required data: this means essentially having a constant input for such relationships. There should also be constant input for frequent requests and a knowledge of source for infrequent requests. In other words, environmental data are acquired and stored and supplied according to need. The system should be responsive to all requests for environmental data, including the once-in-a-decade type, but the location of such data in the system and the format of its output should be determined by frequency and priority of need.

(3) Priority inputs. To limit the size of the transformation process (but not the data bank, which should include all known relationships and sufficient environmental data, as defined above), four inputs will establish priorities for region, operation, weapons systems, and environmental impact:

(a) Priorities will be assigned to such regions as may be considered strategic for naval purposes.

(b) Each such region will be defined in terms of probable operations.

(c) Each operation will be defined in terms of weapons systems components priorities -- which are most critical, least critical, etc., to success of the operation.

(d) Each component will be described in terms of its sensitivity to environmental impact.

OUTPUTS

We previously specified three levels of outputs, the first being priority information on region and operation; we have now categorized this as an input, leaving two levels of outputs: command level and support (operating) level (Figure 11). The distinction between these two levels is the same for all functions: command level outputs are limited to high priority regions and operations, and to critical and sensitive weapons systems components. Management can thereby measure its research and development programs in terms of how well they are adjusted to the Navy's most urgent needs, and those in command of strategic planning and operations will have only the information they need to support the level of decisions they must make. Otherwise the output is designed to meet the purposes of the particular function. To the extent that these can be anticipated at this point they are:

(1) For environmental research. Environmental unknowns (needs-to-know) about distribution, probabilities of occurrence, intensities, predictability, relationships with other environmental elements, etc.

(2) For weapons systems development, test and evaluation. We arbitrarily divide this process into applied research and all aspects of development:

(a) Applied research - all unknowns about environment-weapons systems relationships.

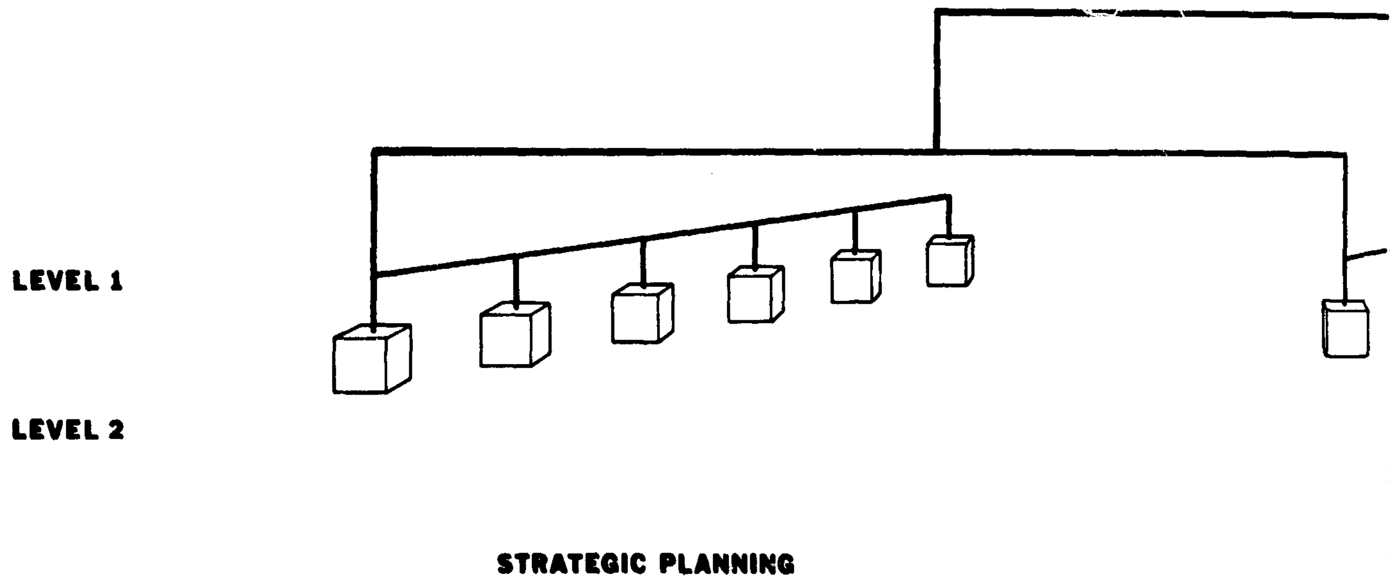
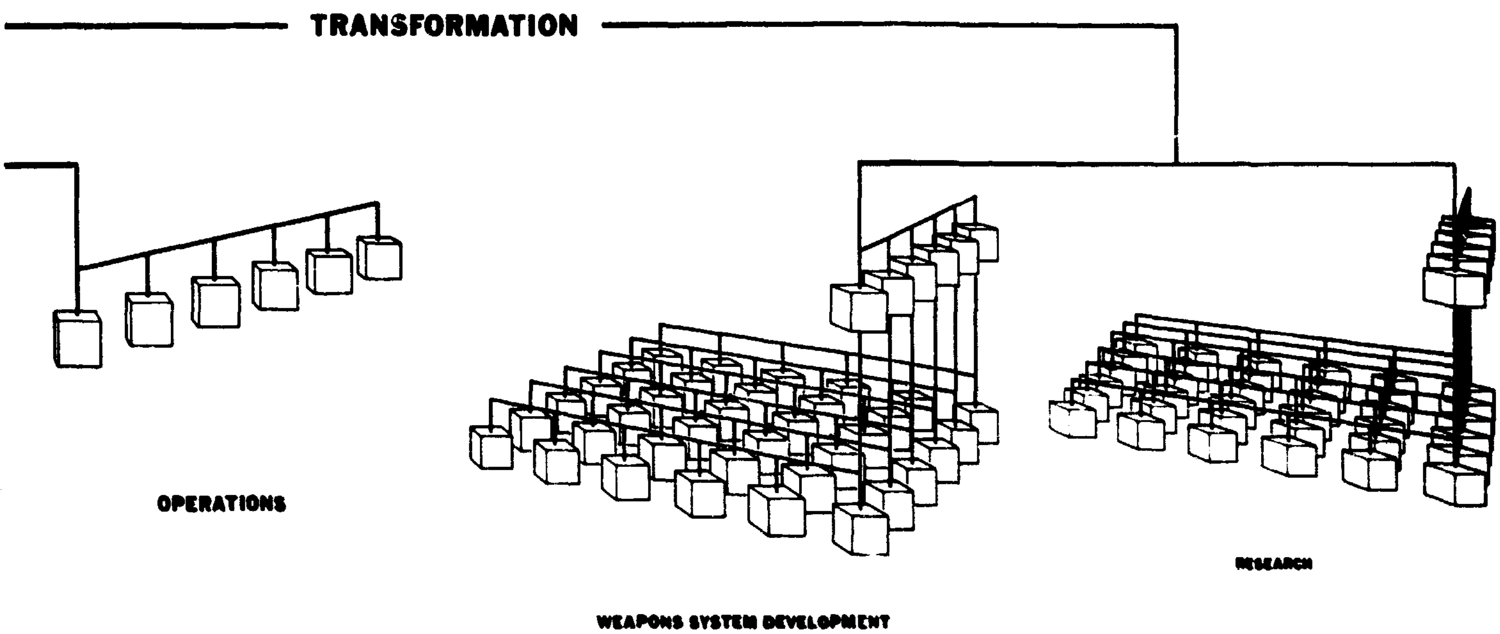


FIGURE 11 OUTPUT STRUCTURE



!!

JCTURE - COASTAL INFORMATION SYSTEM

(b) Development - all data on relationships, in support of improved design (application) or improved use (adaptation). All environmental data for the specific conditions of design indicated in GOR's and related documents.

(3) For strategic planning:* statements of the nature and extent of probable environmental impact on weapons systems components available for use, giving modifying place, season, and time of day options.

(4) For operations:* statements of the nature and extent of probable environmental impact on weapons systems components being used, giving such place and time options as are possible.

* To an important extent the support or operating level data in these cases are instructions about optimum techniques of operation, supplied either in actual training or in training manuals and therefore given only to the operator or user of specific components (Level 2 deleted, Figure 11).

TRANSFORMATION

Given these inputs and outputs, it is now possible to be more specific about the transformation processes:

(1) Translation. The major data change process involves the two activities at the center of the naval ecology model: (i) aggregating impact data by weapons systems, and

(ii) assigning weighting factors to components according to the importance of their contribution to an operation. The technique of using these methods to translate relationships data into probable impact statements will be a major factor in developing the system.

(2) Selection. By far the most prevalent process is simply selecting appropriate data according to functional needs or according to specific requests to the system: the interlocking categorizations and real interdependencies of the three classes of inputs make a wide variety of selection systems possible, particularly in an automated system.

(3) Marshalling. Routing only relevant data to potential users is a very powerful aspect of transformation. Marshalling also routes relevant data to translation and selection.

Evaluation. In our various attempts to diagram aspects of a postulated -- as opposed to real -- system (Figures 7, 8, 10, 11) we have avoided designating elements of naval organization. There is a tendency to equate research with ONR, development with the laboratories, strategic planning with CNO and operations with Fleet. However, the name and locus of such a system, the sources of its data, and the agencies to which the outputs go all remain relatively abstract. It would serve no purpose to attempt to identify elements of organization prematurely, and as our proposals

for initiating development indicate, this is a process in which the initiative must come fortuitously -- from the agency or agencies which perceive the requirement.

Our basic evaluation of this exercise is that if it is important to the Navy to have such an information system -- then it is possible to develop one. The rudiments of both the science and the information system exist now. By understanding and carefully working out the process of development, one should be able to upgrade these rudiments into effective systems rather soon.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

In our original proposal to ONR (September 1967) we said, "The problems of structuring (a coastal information) system are vast, while the problems of implementing the system, once it is structured, are minor . . . . Therefore, this proposal is addressed to the problems of concept and structure which must precede implementation."

Unless we are badly mistaken the problems of concept and structure were not so vast as we thought at the time -- if our solutions are acceptable. Meanwhile, in the process of working on these problems we believe we have learned something about the process of implementation.

Conclusions

We have concluded that environmental impact on naval operations is significant; that the rudiments of the science describing and measuring this impact exist (we refer to this as naval ecology); that an information system can be created, based on principles of naval ecology, which as it evolves will improve naval effectiveness.

We believe that such an information system will provide the focus by means of which an effective interaction can be established among the four basic Navy functions -- strategic planning, operations, weapons systems development, and

research; will provide the stimulus for defining and acting upon principles of environmental interaction; and, therefore will have a desirable impact on system effectiveness. This belief is based on evidence of the pervasive influence upon organizations of the introduction of systematic data marshalling -- typically of accounting systems, of logistics and personnel information systems -- in fact most management information systems.

Recommendations

Our conclusions led us to two distinct but interrelated recommendations: development of a body of coordinated knowledge termed "naval ecology" and creation of an information system. The first can best be described as empirical research -- the patient piecing together of empirical data into a useful and valid body of knowledge. The second is part adaptive innovation, part technology, part management. In the process of developing both an understanding of environmental interaction and applications of that understanding, the two activities are necessary, because it is on the basis of a framework of environment-weapons systems-operations relationships that all levels of an information system can eventually be created.

Recommendation 1. Construct an Empirical Model of Naval Ecology Based on Data From Service Laboratory and Engineering Centers

Our discussions with naval laboratory personnel indicated in many cases a real concern with environmental impact. A large proportion of the studies carried out at the Naval Civil Engineering Laboratory, as indicated previously in this report, had to do with one or another aspect of environmental relationships. A survey of the Technical Abstract Bulletin showed titles of apparently relevant reports from the following naval installations:

Naval Weapons Center
Naval Ship Research and Development Center
Mine Defense Laboratory
Naval Inshore Underwater Warfare Group
Naval Underwater Warfare Center
Naval Air Development Center
Naval Air Engineering Center
Naval Avionics Facility
Naval Medical Field Research Laboratory
Naval Medical Research Institutes
Naval Missile Center
Naval Oceanographic Office
Naval Personnel Research Activities
Naval Radiological Defense Laboratory
Naval Supply Research and Development Facility
Naval Training Device Center
Naval Underwater Weapons Research and Engineering Station
Naval Weapons Laboratory
Navy Electronics Laboratory
Navy Marine Engineering Laboratory
Navy Underwater Sound Laboratory

For a variety of reasons there is no attempt to correlate such studies, except on an individual basis, and there is no central clearing-house of engineering reports. Within Navy

there is nothing standard about the bibliographies that are published. Functionally oriented organizations in topically oriented societies simply do not encourage complex, interdisciplinary collaboration.

In addition to such reports, COMOPTEVFOR regularly tests naval materiel (in our language, components and subcomponents), in operational and geographical environments; there are hundreds of reports specifying the findings of such evaluative procedures.

Therefore, it seems desirable and feasible to begin to construct a model of the applied science, naval ecology, using the empirical data reported in naval studies such as those referred to, plus studies made by similar organizations in Army and Air Force. The suggested approach relates directly to the functions and categories and relationships diagrammed in Figure 7 (particularly the basic data phase) as well as to the information system portrayed in Figure 10:

Step 1. Collect all available relevant bibliographies from all services, and concurrently,

Step 2. Select either all reports dealing with vehicles and structures, or a very large sample of all such reports; select from these reports only those in which the relationship between the thing reported on and environment is stated verbally and the conditions of the environment producing the relationship are in some sense quantified.

Step 3. Extract data from all such selected reports, coding the data in a wide variety of ways; for example:

* Hierarchy of components and subcomponents

```
landing craft
  electronics systems
    navigation
      circuitry
      transistors
    communications
      etc.
engines
  electrical systems
  etc.
hull
  etc.
```

* Functional category or categories reported

```
use
test
transport
storage
maintenance
```

* Operation or component of operation

```
amphibious
  landing craft
  helicopter operations
    surveillance
    personnel movements
  etc.
```

* Description of the relationship

```
corrosion          trafficability
erosion            mobility
shorting           habitability
fouling
swamping
pollution
rusting
```

* Functional outcome of relationship

  degradation
  deterioration
  malfunction
  fatigue
  failure

* Environmental situation producing specific effect

  sea state
  visibility
  soil bearing ratio
  slope
  humidity
  barriers

* Measurement of environmental situation producing extreme effects:

  function failure or serious restriction
  movement prevention or serious inhibition

* Techniques for offsetting undesirable functional outcome

application	adaptations
coating	air conditioning
insulation	treatment
new materials	preservative

Step 4. Broaden scope to include all categories of components and subcomponents for which data exist.

Step 5. Perform machine analyses of collected data; for example:

* Aggregate data by incidence of (e.g.):

  Kinds of effects for major components
  Functional categories reported for major components
  Relationship descriptions for major components
  Functional outcomes by subcomponents
  Extreme effects by major components

* Analyze data in a variety of ways, e.g.:

  Specifications of environmental situation by effects
  Specifications of environmental situations creating extreme effects by major components
  Specifications of environmental situations creating extreme effects by operations and components of operations

Step 6. Attempt to construct an empirical model of naval ecology, based on the previous analyses, such that given an operation and its major weapons systems components one can predict:

Components most likely to be affected by environment
Components most likely to be extremely affected by environment

Step 7. As outcome of model construction attempt, point up areas of ignorance, as follows:

Missing axes in the coded data of Step 3, by components and subcomponents
Components not reported
Environmental information necessary to predict, for example, geographical areas exhibiting extreme effects for specific components.

Recommendation 2. Design a Prototype Coastal Information System for Amphibious Operations, Command Level Outputs

An information system can only be usefully introduced by the people who will manage it, contribute to it, and use it -- because it is a product of all these things. This is the basic argument for building on present systems, for providing constant tests of system effectiveness, and for carefully choosing the techniques of development, system hardware, and above all, the format of outputs.

Our philosophy thus far has been to develop concepts and structures which are meaningful to the present Navy. It is for this reason that we have sought our data (for the systems analysis we have undertaken) from the Navy itself. The major distinction between our concepts and actual Navy practice is a distinction between the way organizations function and the way information systems function. Information systems, as opposed to data flows, are relatively new concepts. And the real significance of information systems, we believe, is their capability of increasing organization effectiveness without necessarily changing organization structures.

In other words, we believe a weapons-systems oriented environmental information system may do far more than improve decision-making and systems operation effectiveness; it can

create common goals meaningful to all functions, and in doing this it can create a common language which will unite for more effective performance the diverse human elements -- officers, engineers, scientists, administrators -- who make up a complex organization like Navy.

But it can only do this if it reflects the present capabilities and outlooks of these people. Its purpose is not to replace any present functions, but to support present functions in such a way that both effectiveness and development are improved. Our suggested approach to creating a prototype coastal information system for amphibious operations for command outputs will therefore be based on two analytic exercises incorporating Navy logic and procedures: one will be an operational monitoring of an amphibious planning exercise; the other will be a systems analysis of an amphibious operation aimed at establishing sub-operation priorities and environment sensitivity. The system itself is based on the general design reported on the previous pages.

In this way we can be sure that the information system does not go beyond the state of the art of amphibious warfare and that it does not contain what data-recipients would consider irrelevant data. The "new" element added will be the transformation process, which will both translate and marshall information to expedite the communication process among

Navy functions as these bear upon amphibious warfare and its related weapons systems.

One thing that must be kept in mind is that no coastal information system is going to provide all of the coastal data that individuals want. It is safe to say that collection activities -- across the whole spectrum of sophistication from an orbiting sensor to a frogman's estimate of wave heights -- go on throughout the Navy, in all functions. This will continue. But the collection syndrome is a sensitivity to be built upon, not a condition to supercede. In other words, a Navy coastal information system will perhaps contain only a fraction of all coastal data collected within the Navy alone, but the data it does contain should be high priority, critical, extremely relevant -- it should, in fact, be a basic resource for decision-making of a sort that shows the close relationship among all Navy functions.

Suggested Approach

Essentially four interrelated but separate work phases are planned:

(1) One is the detailed monitoring of an amphibious planning exercise, in which Matrix personnel will not only observe, record, and question, but will also discuss with Navy and Marine counterparts the nature of every point in the exercise at which environmental data are brought to bear or are not but should be brought to bear in someone's opinion. This will acquaint the Matrix team with the environmental components of Navy planning procedures and the Navy-Marine team will be sensitized to environment as a pervasive factor.

(2) A second is the analysis of an amphibious operation, the two immediate objectives being (a) to establish a range of priorities for events and the weapons systems supporting those events, and (b) to establish critical environmental parameters for high-priority-event systems (see previous chapter). These procedures should limit the universe of possible environment-system relationships to those which are really critical for command decisions for strategic planning and operations, should reveal critical areas of environment-engineering priorities to development, and may reveal as research guidelines areas of ignorance of environment-weapons systems relationships or of basic environmental knowledge.

(3) The third is design of the system, following the system definition of the previous chapter, which involves specifying data outputs to each of the four functions in terms of their own requirements, and in terms of a specific location. This means providing the strategic planner with critical environmental parameters for high priority events in amphibious operations, as well as with the probabilities that "inhibiting" or "preventing" levels of these parameters will be reached at a specific location at various times.* It means providing the commander of an operation with similar data for a specific location for some more limited time options, so that the predictions are more precise and presumably more accurate. It means providing the development engineer with information about the weapons systems components which are both critical to the operation and most environment-sensitive, and therefore least reliable. It means providing test and evaluation with sets of significant questions about system components, questions which cannot be answered with current knowledge. It means providing research with similar questions -- about the incidence of environmental conditions,

*It may also be possible, although probably not in the course of this study, to provide a decision-making matrix for the likely situations in which there is no straightforward "go-no go" condition, but rather a mix of different levels of environmental impact upon various aspects of the operation; for example, there may be a serious inhibition of supporting air operations but ideal sea state for amphibious landings, and these are the marginal decision-making situations in which some objective help is useful.

about the predictability of certain environmental factors, about the interrelationships of environmental processes, etc. -- which cannot be answered with current knowledge and which relate directly to high priority events in amphibious operations.

The process of translating environmental data into information outputs such as these and directing them to the proper recipient is a significant part of the transformation process. The chief task of this work phase will be to create a process of translating data in ways which hopefully can be duplicated by computer programs. A subordinate task will be to identify data sources which can currently be used as inputs, as well as requirements for other data sources which do not now exist.

(4) The fourth is system evaluation.

The entire process is aimed at demonstrating that it is possible to create a manageable system which provides only high priority data in a translated form of immediate relevance to its recipients, a system which at the same time provides different Navy functions with an additional common basis for interacting -- i.e., the environment-weapons system relationship.

The prototype will apply to only one operation in one location for command outputs alone. Thus it is only a small beginning. However, even this beginning will be designed selectively to provide data for only critical events and environment-sensitive system components used in those events. Thus

the system will be designed to meet urgent requirements at the outset and to establish priorities for decision-making in the various functional areas it serves. Its overall priority depends only on the importance the Navy attaches to amphibious operations as compared with other types of operations.

Work Phase 1. Monitoring a Simulated Amphibious Operation

It is the basic purpose of this work phase to examine the information flow processes during the development and simulated execution of an amphibious operation to determine current practice regarding the use of environmental data. The monitoring process is used to establish: 1) the form, content, and significance of required environmental inputs to planning, 2) the identity and functional relationships of filter sources to the planning organization, 3) the synthetic processes required of filter sources and their rationale for data reduction and interpretation, and 4) the data sources upon which filter sources rely and the forms in which data are transmitted to them, all of which concepts were developed this past year.

These things are to be achieved by means of the following work steps, which are stated here in great detail inasmuch as this technique has not been used in previous phases of the

Coastal Information Project:

(1) The Navy and/or Marine Corps initiates a planning program for a typical operation and Matrix personnel monitor the planning operations.

(a) Determine the planning staff composition:

i) By command relationships.

ii) By function within the command.

(b) Assign Matrix staff members:

i) As counterparts to those planning staff members whose functions particularly relate to environment.

ii) As a counterpart of the decision level.

(2) In those areas of the planning and simulated execution of the operation relating to the coastal environment, Matrix monitors have access to the number of environmental parameters, the form in which the information is supplied to the planning organization, the method of information transmittal, the origin of the information, and the time sequencing of information flow to the planners.

(a) Establish Matrix participation ground rules to the operation to allow:

i) Interruption of the activity to examine the environmental parameters made use of in the operation. The interruptions allow

Matrix counterparts to record:

- o Nature of requirement from planning.
- o Origin of requirement from planning.
- o Form of requirement from planning.
- o Chronology of requirement from planning.
- o Information source used.
- o Time duration between request and response.
- o Form of response.
- o Content of response.
- o Their (and their operations counterpart's) judgments of the response into the planning operation.
- o The judged adequacy of the response by their planning counterparts:

  (If adequate, Why?)

  (If inadequate, Why?)
- o The relevance of the information to the plan as judged by its use in the plan and/or the judgment of counterparts.
- o The significance placed upon the information at the decision level.

ii) Recording the chronology of events in the overall planning and simulated execution of the operation.

(3) In addition to monitoring the planning and execution processes, Matrix staff examines jointly with the Navy/Marine Corps planning staff:

(a) The relevance of the requested information to the operation.

(b) The usefulness of the information in the form delivered to the operations planning group.

(c) Those areas relating to environmental parameters which would be useful, perhaps crucial, to the operation but which currently are not available or might never be available to planning.

(4) Following the exercise Matrix examines the information inputs into the operation to establish:

(a) The information inputs of the planning-execution exercise.

(b) The input information used in the planning-execution exercise.

(c) The input information that may not have been used for reasons of:

i) Irrelevance

ii) Delivery in unusable form

iii) Untimely receipt of information

iv) Other

(d) The information of use and critical to the planning-execution of an operation as conducted.

(e) Estimates of the time sequencing of information input requirements.

(f) Estimates of the adequacy of form and content of current input information.

(g) Conceptualized computer-assisted input systems to the planning and execution efforts.

(5) Examine the information filters between the planning and execution levels and data acquisition for:

(a) The determination of data sources used in their activities.

(b) The form of the data or information which they use (i.e., raw data, semi-processed, processed and interpreted) in the filter process.

(c) The synthetic processes used in providing information to the planning and execution levels of use.

(d) The quantities and types of information and data gathered.

(e) The quantities and types used in the synthesis.

(f) The types of operations to which they provide inputs -- if more than one.

(g) The suitability of current information inputs into their filter system.

(6) Examine the data sources utilized in the operation to:

(a) Determine estimates of reliability of sources.

(b) Establish whether alternate or more extensive pertinent data might be available from other sources.

(c) The time requirement between data collection and transmittal to filter sources.

(d) Conceptualize computer-assisted data transmission to filter sources (which may become a computer activity).

(7) Conceptualize a computer-assisted program from data collection to the planning-execution level.

Work Phase 2. Systems Analysis of Amphibious Operation

It will be useful to think of an amphibious operation as a system the output of which is attainment of a stated mission. The mission, which is a very general statement of accomplishment, can be broken down into more discrete components: mission into supporting goals, goals into supporting objectives, objectives into required events or activities (the transformation process), activities into weapons systems components, or man-machine-materiel combinations (the inputs). The analysis will be based upon Navy-Marine perceptions of such an operation, and it will

provide nothing new except that it will structure and specify the logic of the relationships of people, materiel, activities and achievements.

This arrangement will enable experienced people to make better judgments about, for example, the priorities of activities with respect to mission fulfillment. It will enable Matrix personnel, who are well acquainted with known data on environmental impact on men and materiel, to select critical components to identify in some range of environment-sensitive priorities. In effect, the objective of this phase is simply to reduce the complexity of environment-amphibious operations relationships to their most basic factors.

The steps involved are:

(1) Analyze amphibious operations. Ask experienced officers to review and criticize analysis. Ask same officers to assign priority system (1, 2, 3) to each level of system outputs and to each activity package.

(2) Identify environmental parameters for all weapons systems components involved in high priority (1) activities.

(3) Classify components according to sensitivity to environmental effects: i.e., those which are prevented by some environmental condition of low-to-medium frequency of occurrence or those which are inhibited by some environmental condition of high frequency of occurrence.

Work Phase 3. Designing a Coastal Information System for Command Outputs

Working out the ecology of system components for a specific location will require the following steps:

(1) Analyze environment-component relationship: set "prevent" and "inhibit" conditions if possible.

(2) On the basis of above analysis, provide strategic planning outputs indicating probability of encountering "prevent" or "inhibit" conditions at various times, indicating basis for making such judgments from data so translated.

(3) Where information deficiencies exist in either (1) or (2), indicate type: e.g., nature of impact relationship, basic data, etc.

(4) For all "prevent" or "inhibit" conditions for some specific time period (e.g., two weeks), provide operations outputs indicating probability of existence of such conditions, indicating basis for making such judgments from data so translated.

(5) Provide development outputs of following types: all critical components with high environmental sensitivity; all areas of ignorance of environmental impact relationships.

(6) Provide development outputs (test and evaluation) with all known relationships and specific "prevent" and "inhibit" conditions.

(7) Provide research with all translation procedures, particularly those which involve excessive extrapolation or interpolation and those with low reliability quotients (particularly some aspects of prediction); also provide all required new forms of data (not routinely collected), which may either have to be inferred from present, related data or collected in appropriate form; also provide all relationship problems.

(8) Decide on appropriate format and language for all outputs (2, 4, 5, 6, 7) with recipients.

(9) Specify data sources to be used on a regular basis.

(10) Briefly evaluate programming complexity and other problems involved in automating such a system.

Work Phase 4. Evaluation of Prototype System

Once the coastal information system for command outputs, amphibious operations, has been created, it must be evaluated at input, transformation, and output levels to determine feasibility, acceptance, cost and time factors, etc. The following steps are involved:

(1) Define in detail all required input data:

(a) Definition: units of measure, meaning, significance, and illustrative examples.

(b) Derivation: identification at lowest level and process of development from the lowest level.

(c) Source: where data are now stored and how currently collected.

(d) Format: in what form data are stored, i.e., digital, microfilm, written text, maps, tables, etc.

(e) Quantity: how much information is available and what coasts in the world are covered.

(2) Analyze data list and formulate for feasibility tests. Determine basic data characteristics such as: maximum number of digits to describe; location reference coordinates required; general priorities during Strategic Planning, Operations, Weapons System Design and Development, and Research; minimum processing required under various system concepts; accuracy and validity under initial conditions and under update or system maintenance conditions; quantities per coastal description unit (mile of coastline, unit depth of water, etc.).

(3) Define in detail all translation procedures:

(a) Prediction systems.

(b) Probability statements.

(c) Inference of "inhibit" or "prevent" situations from data.

(d) Statistical treatment of data.

(e) Feedback procedures: areas of ignorance, of excessive environmental sensitivity, etc.

(4) Analyze feasibility of data base structure and computer application. At a relatively high functional level simulate operation of a system -- computer and data base

aspects -- characterized by data as defined in (1), (2) and (3) above. The objectives of the exercise are exploratory: to identify problem areas or weaknesses, to determine need for modification or expansion of basic concepts, and to provide guidance for parallel and future development efforts. Manual, or rather informal, simulation is therefore indicated using the experience gained in Work Phase 1.

(5) Because the most appropriate evaluation probably comes from a careful investigation of the data packages by representative users, it is suggested that appropriate users not only be given the packages but also a thorough briefing on how they were designed, before they are put in final form for a report. Thus any failures to judge correctly the users' acceptance or rejection of such data can be corrected.

Summary of Total Project to Date

SUMMARY OF TOTAL PROJECT: PHASES I AND II

The objective of this project was to design a coastal information system responsive to Navy needs. The project started two years ago. The first year was devoted largely to an attempt to determine outputs (requirements) of such a system, and was reported on in October 1968 (DESIGN OF A COMPUTER-ASSISTED COASTAL INFORMATION SYSTEM: PHASE I. OUTPUT STRUCTURE). In the course of investigating what the Navy thought were its needs for coastal information, we discovered that the appreciation of environmental impact is about as random in Navy as it was several years ago when we studied Navy logistics in this context (ENVIRONMENT AND LOGISTICS, November 1955). It was obvious that we were not going to get very concrete answers about requirements unless we put the question in a very cogent and relevant fashion. This meant developing some framework within which to infer requirements, and

> The basic objective of the project as it developed was to sketch the overall coastal information system as it looks at the moment, identify the problems, constraints, and prospects which face the system, and within this framework make a more precise statement of Navy requirements in the format of an output structure. (Phase I, p. 2)

Our conclusions at the end of the first year were that the next steps were to investigate Navy information flow processes as these involved environmental data, and concurrently to examine the coastal information requirements of

the research function. In other words, we were still concerned with outputs (requirements), but now much more in terms of the bases for such needs instead of the recognition by users of those needs. In the process of doing these things we have looked -- somewhat incidentally -- at the significance to Navy of environmental impact; we have queried naval laboratory personnel on their use of environmental data in weapons systems development. We have investigated at the same time the ecology of naval activities, in an effort to determine how needs for environmental data, and translation of such data to meet those needs, might best be satisfied. We believe we know how to develop the ecological model for such a system -- in effect, putting the integrated picture of naval environments together in such a way that all users can see their requirements as they relate to the requirements of others. We believe we know how to introduce and develop such a system in such a way that it will be a Navy product, not a consultant's dream. And these are our two recommendations for further work.

Because the work of the past two years is a continuous research effort, and because s. eaders of this report might not easily have access to the previous report, we have attempted to summarize the total project in the relatively few pages of this summary. This is not intended to be an abstract of both final reports. There is an abstract for

each. It is intended to be a description of our objectives and our efforts, plus a self-evaluation of progress. Therefore, it is organized in the form of answers to three questions that anyone interested might ask us personally about the work.

Answers to Basic Questions

The work on the first two study phases can perhaps best be summarized by attempting to answer three obvious questions: (1) Why undertake a project to develop a geographical data system which is potentially so large and complex? (2) Why use the systems approach in this undertaking? and (3) Has any concrete progress been made?

Why a geographical data system? There are two answers to this question, both equally important. Note the use of the word "system", implying that the objective is not to create a data "bank" for storing and retrieval of raw data*, but rather

---

* Coastal information can be taken to mean any data which can be identified as applying to some specific coast or coastal location. Such information is geographical because it has a location or space component. Geographical information is almost limitless. It includes information about coastal waters, the physical coast and the atmosphere above it, the man-made structures which occur on or off the coast, and the people who occupy the coast. Such information is the raw material of many sciences; it is structured and classified in a wide variety of ways for a wide variety of purposes, and it is available in a wide variety of forms.

In its present form, coastal information is not an information system. It is a complex of subsystems each meeting different requirements. For example, coastal navigation charts, warning and identification devices, together with such data collection devices as radar and sonar, could be called a coastal navigation information system -- and a highly useful one. Or data classified in such a way as to identify and

to create an information process which accepts specified raw data and transforms them into data specifically tailored to the requirements of various users.

(1) To transform geographical (environmental) data in such a way it is necessary to understand how the environment interacts with men's activities. This is human ecology, one of the least studied "disciplines" in the contemporary scientific roster, yet unquestionably one of the most important to man's survival. ONR's interest in "coastal information" provides the opportunity to study naval ecology, which is different only in general objective from human ecology. While most of the Navy's missions involve deployment of some sort of weapons system, the bulk of the activities and materiel involved in many non-naval activities, especially when one abstracts the nature of the activity -- e.g., movement, observation, etc. Thus the opportunity to study the interrelationships between environment and given sets of men's activities is inherent in the problem of designing an information system, and there is no relationship more fraught with both danger and opportunity in the present technological era: it is, in other

---

differentiate coasts on the basis of coastal processes could be called a coastal geomorphology information sub-system.

The term coastal is a construct, the boundaries and nature of which are not currently definitive but are a function of the collection and the use of data. In this study, coastal information is treated as a sub-set of the universe of geographical data of interest to the Navy.

words, very much worth investigating, both for the Navy and for mankind.

(2) One of the major concerns of the world today is communicating information effectively. As research has proliferated in the post-World War II era, the amount of new information has greatly exceeded the capacity of present communications systems to provide people with the data they could use if they knew about them. This is called the era of the computer because that device has the potential, at least, to help solve the problem. But too often the computer is used simply to store large amounts of information; an analogy would be hitching a horse to a modern automobile. The computer can be most useful if it is used not to store and regurgitate raw data but instead can take the raw data and transform them into much more useful outputs. This general problem has plagued chemistry, in particular, because the discovery and use of new compounds and processes is a very large business. In a less obvious way, but in a way that is now becoming more and more apparent, the problem is plaguing all of the activities which involve a real knowledge of the interplay of environment and human behavior -- city planning, development planning, strategic planning, military intelligence, etc. The fact that geographical data are so vast, encompassing so many different disciplines, and that human behavior in its many manifestations is equally

vast and encompassing, has discouraged the kind of interdisciplinary effort that is necessary if a geographical data system is to be conceived.

And there are certainly problems to be solved before a system is created. These were summarized in our previous report as follows:

> (1) User-oriented problems. The major human problems which affect the effectiveness of an output structure have been discussed:
>
> (a) Perhaps the single most important problem in the development of a geographical information system (military intelligence, urban and regional planning, tax assessment, etc.) is the problem of involving the user in the development of the system. To be involved appropriately, he must have some real appreciation of the rules governing the operation of the system; he must be able to state his requirements for such information; he must be willing to submit to the rigors and constraints of establishing informational priorities; and he must have some comprehension of how the transformation system works and what its language is.
>
> (b) The user must use the system "properly". He must learn to ask questions in operational terms and expect answers in those terms. If, as so often happens, he asks for the answer plus the supporting data, like the commander who wants to look at the weather chart before he accepts his aerologist's advice, the system will not work. (This explains the emphasis on "levels of specificity".)
>
> (2) Data processor-oriented problems. The world of geographical data processing is a complex world of processing and reprocessing. Geographical data which have been collected in verbal, analog, digital, and visual formats are summarized in visual, analog, digital, and verbal formats; they are summarized in terms of hourly, daily, monthly, and annual time units, and they are summarized in terms of every size and shape of areal unit imaginable; they

are generalized in the form of principles of cause-effect relationships; and they are mixed with other kinds of data in varying proportions and summarized again for varying purposes. This is a very normal condition, because so many people are interested in so many different aspects and uses of geographical data. (An analoguous situation might be a telephone system for which the directories were put out for -- and by -- classes of customers on the basis of the major uses of the telephones and geographical distribution, with no capability of pulling all the directories together into one.) It creates serious problems for the data processor. Caught between an array of some ultimate information users and a wide variety of raw- or processed-data suppliers, he finds himself constantly trying to interpret statements of requirements, understand the language and format of many kinds of data, and develop a program which is not only compatible with requirements and data inputs, but also with the hardware available to him and his experience. As a result, he introduces these problems into the system.

(a) Programming problems, which can be interpreted as great investments of time and money in the process of mutually educating user and data-processor to each others' needs. Cost and time constraints, or the inability of the data processor to understand the problem, lead more and more to the use of developed (canned) programs which may meet the user's needs only peripherally.

(b) Output format problems, in which the answers are in a form not intelligible to the user without considerable effort or further education. This is one of the most common problems of users of geographical information, and it is a major obstacle in the way of greater use of computer-assisted systems.

(3) Data collector-oriented problems. It used to be almost entirely the case that when a single scientist collected geographical data for a study he only published the relevant, synthesized data; the rest was effectively "lost". (There is a growing tendency for the individual scientist, supported by an institution, to submit all of his data to the institution for storage.) Geographical data collection of many types has been institutionalized for

a long while (Weather Bureau, Geological Survey, etc.), and has even been focused by many collectors in such efforts as that of the international geophysical "year". Institutionalization is of many types: it may focus on collection as a basis for producing some required output (weather predictions, geologic and topographic maps), or it may simply focus, nowadays, on collection to serve a heterogeneous market of potential users. Two problems arise from this situation:

(a) The data collector who has a "product" in mind obviously collects data in terms of that product -- or should. This is proper: requirements determine the inputs. Such data are not necessarily in a form appropriate to the requirements of other users. But they are very often used anyhow, for the very good reason that the costs of collecting geographical information can be staggering. There is a growing conviction -- among scientists, accountants, planners, etc. -- that sophistication in the techniques of sampling have outmoded such data "manipulation".

(b) The data collector who does not have a "product" in mind is in trouble: he will necessarily concentrate on the means without knowing his end. One result has been, in the modern era, a profusion of sensor-collected data which do not fit anyone's specific requirements.

Why the systems approach? There are many distinct techniques referred to as systems analysis, some of which are extremely formal. In this study, the terms "inputs" and "outputs" have been used to define the boundaries of a discrete information system -- specifically coastal information packaged to meet Navy requirements. Systems logic suggests that if requirements can be specified it is then possible to define the necessary data packages: in other words, if one knows what questions are being asked, one can define the form the answers ought to take. Knowing the form the answers must

take, one can identify the processes of producing those answers (the transformation process), and this in turn begins to identify the form of information inputs to the system. Put another way, one then has some very definite notions about what must be done to attain those goals and objectives. This technique of working backwards ("Give me the answer, and I'll tell you the question") has proved to be an extremely useful way of thinking about complex processes. It is this general technique and logic that has been applied.

However, the application of this technique is perhaps not as neat and tidy as one might expect, and the reason it is not is relevant to an understanding of what is being attempted. Specifically, what is being done here is strictly speaking neither research, which might in this context be defined as developing the concepts basic to such an information system, nor development, which might be defined as putting a system in operation by some specified date. Rather, it is applied research, which might be defined as attempting to develop the format of a system which not only works but whose implementation is feasible.

Our approach has therefore been a mix of theory and pragmatism -- an opportunistic effort to fit our systems analysis procedures to the state of the art of naval ecology. We attempted to specify the kinds of data needed as outputs of the system, but we found that potential users of such a system

had not themselves thought much beyond current weather and sea surface forecasts, if in fact they had thought that far. We then attempted to look back into the system itself to learn if we could why the effect of environment on naval operations had been so little systematized. Within the system -- in the so-called transformation process -- we found bits and pieces of a formal process, but large parts of the structure were missing. We found:

> that a great many geographical information systems and subsystems are already in existence -- within Navy, within the Federal government, and outside government. It is probably true, although this has not been investigated, that the greatest effort and the greatest complexity and confusion characterize the area of inputs, i.e., data collection. It seems apparent that the greatest need is in the area of outputs, and here the effort appears to be least. If these generalizations are reasonably true, then the most immediate potential source of improvement lies in the transformation process.
>
> Although transformation and outputs are entirely within Navy jurisdiction and control, the institutionalization of various processes which in one form or another involve collection, processing, use, and distribution of coastal data has made it necessary for Navy to accept data from outside the system. These come as directives or as a result of shopping around for information within the Navy, within the Department of Defense, within the non-military agencies of the Federal government, and outside government entirely in some instances.
>
> The information gathered from these varied sources may be in the form of relatively "raw" geographic data, or it may already have been processed in a variety of ways: e.g., synthesized and summarized geographical data (mean monthly temperatures, soil maps); principles defining relationships (x rainfall on y soil = mud type z); geographical

data combined with other forms of data (clothing allowances for a particular climate); such synthesized data translated into operational statements (map showing landing beaches); or even eventually into "yes" or "no" answers to operational questions.

This information is not defined as part of what has been described as the inputs structure. Instead, it is part of the transformation process and rarely in "final" form for use in making command and support decisions. It is not, in other words, the kind of information that would be in an output structure if there were one. It is the kind of partially processed information presently provided to answer the kinds of questions that are being asked, supporting the decisions that are being made.

The transfer of this information to an output structure cannot be described, except in an extremely fragmented fashion, because there is no formal output structure. There can, of course, be no formal source structure if there is no output structure. To analyze the data flows and the processes by which they are generated, it will be necessary to impose some kind of pragmatic, conceptual, organizational framework upon transformation processes and output structure.

The purpose in doing this is to be able to make some generalizations about the transformation processes presently at work and to what extent they appear to be equivalent to requirements. It is a reasonable assumption that the points at which the "real" system and the "ideal" system do not match are points about which some management decisions can usefully be made.

In other words, our approach was pragmatically conceptual. We knew that it was worse than useless, even if possible, to tell potential users what data outputs they needed. We therefore decided to erect as much of an ideal (theoretical) system as we could and compare it with as much of the real system as we could identify. Our emphasis was still on outputs, but we looked back into the system as much as we felt was

necessary to rationalize the "real" and the "ideal" output structures. As a result, we feel we know about how far one can go in creating a partial coastal information system which will be acceptable to and understood by Navy users and which, hopefully, will demonstrate that a total system is needed and will eventually be developed.

We have not considered inputs, except tangentially, both because: (1) we are in no position to specify inputs until specific transformations to produce specific outputs can be described, and (2) environmental data collection and storage is big business; the problem within Navy will be to satisfy all users, but the problem outside Navy belongs to someone else: Navy can request selected data collected by other agencies without attempting to modify the collection programs of those agencies.

We think the approach has been effective. A review of the first report in Computing Reviews, June 1969, said that the problem attacked "may be regarded as the analysis of an extremely complex management information retrieval system, perhaps the most complex tackled thus far." Despite this, we feel we have in two years of what can really be described as "exploratory" effort come a long way toward: (1) specifying the design requirements of a coastal information system; and (2) pointing out the changes in present partial systems which must precede eventual development of a total, responsive

system. Just how far we have come is of course the subject of this report, summarized in our attempt to answer the next question.

Have we made any concrete progress? We hope and believe we have. But since this is applied research, we have attempted to follow what appeared to be optimum paths rather than stick to a precise study formula. This business of following our noses has probably saved time and money in the long run, but we have also been up some blind alleys. We hope to be excused for emphasizing our findings instead of our mistakes and in organizing this report according to fundamental concepts instead of as a history of what we have done. However, an historical record of our progress may be useful, and it is sketched out here to provide a background for this report.

Proposals. We have submitted four proposals over the last two years. The first was to study requirements -- the needed outputs of such a system. The second was a small investigation of the sensor problem -- in effect, the problem of automating inputs to such an extent that the human beings who still constitute the vital connecting links in the whole information hardware system can't maintain the pace. The third was a pragmatic approach to the transformation problem -- an attempt to find out what was happening, and what should happen, at theoretical interfaces in the system if postulated outputs were to be achieved. The fourth was an

attempt to determine the actual coastal information outputs that would exist in the research function area, basically by extending the concept of three dimensional matrices that was used to visualize the output structure.

Evaluation. Of these proposals, that with the least direct application was the second -- to study the sensor problem. However, it did lead us to an evaluation of automation as an adjunct of information systems in general, and we came to a conclusion that may not generally be appreciated: that automation is neither the problem nor the solution to the problem of designing most information systems. Automation has been applied, without much change in extant systems, to data collection, storage and retrieval. It is possible, although we do not plan to investigate this, that automation has in these processes contributed as much to confusion as to efficiency.

Of these proposals, that which was based on wrong assumptions was the fourth -- to determine actual data outputs at Levels 2 and 3 of the research function. We thought research would be the most familiar (to us) function, and therefore the easiest to analyze. Actually, it turned out to be the most complex function of all, the implications of which in Navy we had not understood (a problem of instit"tionalization of a function), and very complex. What we should have

suggested analyzing (and what we did investigate) was the development function.

The other two proposals were much to the point, and we have in fact achieved more than we thought we might at this point.

<u>Achievements (1st year)</u>. Our achievements for the first year are best summarized in the final report:

> The basic objective of the project as it developed was to sketch the overall coastal information system as it looks at the moment, identify the problems, constraints, and prospects which face the system, and within this framework make a more precise statement of Navy requirements in the format of an output structure. (p.2)

We had discovered that: (1) there was only sporadic recognition of the influence of coastal environment on naval operations, largely experience-based, and chiefly of the most obvious, cyclic elements -- weather, tide, sea state, etc.; (2) that such data as were provided in an organized form (Fleet weather service, intelligence estimates, etc.) were -- in terms of our limited sample -- largely in "raw" form -- i.e., not translated for the user; (3) that there was no basic philosophy about environment, as there was about "logistics" or "intelligence".

In this situation it was next to impossible to get concrete -- and comparable -- answers about required outputs of such a system. So we organized data from interviews with representatives of about 40 Navy offices and developed a

theoretical structure of outputs, which in effect achieved three purposes: (1) it provided a systematic and realistic way of reducing the infinite data potential in the term "coastal"; (2) it suggested that different levels of users require different kinds of data (which will of course ultimately determine the mechanics of the system); and (3) it suggested the kinds of relationships that needed to be understood if outputs at each level were to be relevant.

When we asked ourselves why the need for such kinds of data was not recognized, we had to look back into the data flows and uses within Navy for the answer. The only way to do this effectively, we felt, was to postulate what ought to exist to support such an output structure and then determine whether or not it did in fact exist. Therefore, we assumed that four basic naval functions had to be supported in some fashion by coastal data, which had to be collected and flow through Navy somehow to get to the proper destinations. The question we asked ourselves was this: "Given these basic naval functions (strategic planning, operations, weapons system development, and research) and given movements of coastal information into and through the system, what would be the general structure of coastal information outputs designed to support the functions, and what would be the pattern of information flows designed to support the outputs?" We looked at the Navy realistically as a system, but without

putting institutional labels on the system components. Our approach was, or was intended to be, pragmatically conceptual. It led us to two major conclusions.

Our first conclusion was that coastal information was indeed required, and to a lesser or greater extent used, at both the command and support levels of decision-making for the four basic naval functions -- strategic planning, operations, weapons systems design and development, and research. Both logic and experience indicate the importance of terrain, humidity, sea state, and the like; and bits and pieces of formal data systems, some of them very large, do exist. There is a lack of overall coordination; there are many system lacunae; some aspects of a system are grossly overdeveloped and some do not even exist. Nonetheless, it is possible to think very concretely about a total output structure for a potential system.

Our second conclusion was that coastal data did flow into and through the system and were being transformed into useful outputs. We postulated that the transformation processes were defined by such terms as selecting, filtering, monitoring, translating, factoring, relating, summarizing; that they represented key relationships within the system and with other systems; and that these relationships could be "located" at three interfaces. What we meant was that at three "locations" in the system the characteristics of

competing, or at least different, functions had to be resolved in Navy's favor. One of these was the point at which coastal data entered the Navy system from outside sources, and here all relationships other than the environment/military operation relationship were filtered out. Another was the point at which areas of the world unlikely to have any significance to Navy in the foreseeable future were screened out. A third was the internal Navy bias which translates most naval requirements in terms of weapons systems.

As we have defined them, the interfaces are conceptual. But they should exist in a functional sense if not in an institutional sense: that is to say, someone, somewhere in Navy, should be involved with these interface functions, because coastal information does in fact move into and through the system.

In terms of these concepts we drew up the Coastal Data Flow Information System (Figure 8). On the basis of this we suggested in our first report that the second year's effort be an examination of the real system as compared with our conceptual system:

> The purpose in doing this is to be able to make some generalizations about the transformation processes presently at work and to what extent they appear to be equivalent to requirements. It is a reasonable assumption that the points at which the "real" system and the "ideal" system do not match are points about which some management decisions can be made. (p.59)

2nd year. Our second year's work focused on an attempt to reproduce "real" and "ideal" -- or better "theoretical" -- systems as a basis for such a comparison. These systems were developed on the informational basis of interviews with well over a hundred people in some 50 naval offices and installations (Appendix I); examination of many reports on environmental investigations, chiefly by naval laboratories, plus an investigation of report titles from relevant military organizations in the Technical Abstracts Bulletin; analysis of weapons systems requirements documents for both Navy and Marine Corps; examination of a number of operator's manuals, handbooks, training guides, etc.; and analysis of reports of environmental data collection and distribution systems within Navy, to the extent that the latter were unclassified and readily available.

Our representation of the "real" system is shown in the diagram _The Role of Coastal Information in Weapons System Development_ (Figure 9). The heart of the system is the feedback of requirements for new or modified weapons systems, which ties research and development functions into the system, but the purveyors of environmental data are also shown in their relationships to all naval functions -- which are here

institutionally labeled. A comparison of this system (Figure 9) with the system postulated in our first report (Figure 8) dicated the following:

(1) There is a greater emphasis on weapons systems as the common denominator of Navy coastal data requirements than we had previously thought, although we did recognize the existence of a weapons systems interface. Essentially command decisions are based on three kinds of information: (a) "intelligence" -- information about the enemy -- forces and location, targets, resources, means of production and transport, etc., deployment, and much of this could be termed geographical or coastal; (b) "logistics" -- information about his own weapons systems, their magnitude and striking power; and (c) "operating environment" -- information about the best location and time options that can be chosen for weapons systems use, and all of this can be termed coastal, if the coastal zone is the operating environment.

The present situation is that environmental data must compete with intelligence and logistical data in naval management information systems, and the following statements constitute our present evaluation of the "status", and therefore the competitiveness, of environmental data: (a) many environment-weapons systems relationships are perceived intuitively but have never been specified in a design-effective manner;

(b) perception of importance of environmental impact varies widely, a factor of job, experience, and training; (c) study of given relationships tends to be a product of a locally perceived requirement, and the publications of separate study agencies never get into the mainstream of the system or centralized in a body of knowledge; (d) as a result, knowledge of specified relationships is widely scattered; frequently important findings are not published; (e) chiefly the go-no go impacts are considered, while those which reduce output effectiveness or increase input requirements are ignored as being manageable by the weapons system; (f) the sensitivity of weapons systems to environment varies a great deal, and the first attempts to implement a data system should be in conjunction with the most sensitive weapons systems.

So in no real sense does the weapons systems "interface" exist. If it did, there would be an information flow correlating the four functions in terms of impact of environment on weapons systems -- i.e., in terms of the kinds of environment-weapons systems data each function requires for its own purposes.

(2) The relationships interface, which we postulated as being outside Navy, exists nowhere.

(3) The priority interface probably exists in some fashion. We did not attempt to determine to what extent it

did, because: (a) the information would undoubtedly have been highly classified, and (b) there is no point in factoring the data in this real-region-and-operation fashion until some semblance of a coastal information transformation process is set up.

Another conclusion was that our conceptual system was very fuzzy -- a mixture of functions and institutions, and we attempted to develop a new theoretical system that would meet the objections of the present real system. As a basis for doing this we attempted to synthesize what we had learned, and in good Navy fashion reduced this to four basic "lessons":

(1) Although our study did not have this objective, we felt we had incidentally discovered a good deal of evidence supporting the assumption that environmental impact was a significant factor in the effectiveness of naval operations.

(2) Everything pointed clearly to the importance of the critical environment-weapons systems relationship, which we chose to refer to thereafter as naval ecology -- the science of the interactions between environment and men-and-machines in discrete naval activities.

(3) Since the functions we had postulated reflected Navy thinking and usage, it became necessary to find out

just what "research" and "development" meant in Navy, because this became an important aspect of marshalling procedures in an information system designed to be responsive to naval needs.

(4) Finally, we discovered that an information system is an extremely sensitive and at the same time powerful process: there is more to it than putting data into and out of a system. To be introduced successfully, it must reflect current thinking, with an open-endedness that encourages change. If it is introduced successfully, it becomes a powerful agent for organization and change.

Investigation of these "lessons", which constitute the chapters of this report, led us to design a model of "naval ecology" (Figure 7) and a new theoretical model of a coastal information system (Figure 10). In effect, these models constitute our major findings:

(1) That it is possible to begin to build from present knowledge of the effect of environment on single components of equipment, or materiel, or people -- stated in such terms as trafficability, rusting, fatigue -- an aggregated and extrapolatable body of information concerning the effect of environment in a specific region of the world on a given operation; and

(2) That it is possible now to introduce a partial prototype coastal information system which will produce command level outputs to all four functions for an amphibious operation.

Our recommendations for following work are that precisely these efforts be undertaken.

APPENDIX I

GOVERNMENT OFFICES VISITED

Commander Sullivan
OP-343 Amphibious Warfare

Dr. Sachs and Mr. Goodman
OP-96 Systems Analysis

Dr. J. Lawson
Director, Naval Labs

Captain Becker
OP-973, Strategic Command & Control Systems

Dr. W. P. Raney, Dr. Waterman, Capt. David Bill,
Capt. Robert Schneiwind
OASN, R&D

Dr. Tierney
Oceanographer of the Navy

Commander Pelton
OP-724, Command, Control & Communications

Commander Harley Wilber
CNA Military Project Officer for "Ocean Surveillance Study"

Mr. Donald Moe
OP-961

Capt. C. F. Helme, Jr.
OP-951, Director Technical Appraisal & Requirements Div.

Capt. J. A. Lovington
CNA, Asst. Technical Director for Naval Matters

Commander B. Ireland
TERRIER/TARTAR/STANDARD Missile Branch NAVORD

Capt. E. A. Short
OP-914, Head Information Systems Coordination & Development Br.

R. L. Wilson
NAVAIRSYSCOMD - PMA 55

Mr. James Martin
Navy Ordinance Lab, Underwater Evaluation Dept.

Capt. V. P. O'Rourke, Mr. John Reproth
NAVAIRSYSCOMP - Director, Aircraft & Air to Air Missile Dev. Br.

Lt. Col. D. C. Stanton
DONO, Plans and Policy

Lcdr. J. J. Maloney
Naval Weather Service Command Hqs.

Commander W. T. Hale, Commander Karl H. Farber
Naval Ships Systems Command Hqs.

Lt.(jg) D. E. Puccini
Navy Oceanographic Office

Lt. J. C. Naquin
Experimental Diving Unit

Lcdr. D. L. Hendrickson
NMC, CNM Designated Projects Officer

Mr. F. Knoop
Naval Facilities Engr. Command Hqs.

Mr. Francis J. Romano
Research Directorate

Commander R. T. Quinn
NAV SHIPS, Applied Research Division

Lt. Col. J. R. Luckett
NMC, Amphibious Warfare Office

J. E. Shreve
NAVORD 0531, Mine Warfare Div.

Mr. C. T. Smith, Mr. F. G. Reilly
NAVORD 0822, Nuclear Applications

R. M. Holcombe
NAVOCEANO, Marine Sciences Dept., Ocean Analysis Div.

L. B. Bertholf
NAVOCEANO, Nearshore Surveys

Commander Kaiser, Commander Stockr, Lt. Col. Stanton
OPNAV 06C, War Gaming

Commander Farber
Naval Ship Eng. Center

Commander Stanley, Lcdr. Marshall
Naval Inshore Underwater Warfare Group
Long Beach, California

Mr. Howard Schafer
Naval Weapons Center - Environmental Criteria Determination
China Lake, California

Dr. G. Gordon Hammer
U. S. Naval Civil Engineering Laboratory
Port Hueneme, California

Capt. S. J. Caldwell
Naval Beach Group One
San Diego, California

Cdr. F. R. Kaine, Lcdr. Connelly
Naval Operation Support Group
Coronado, California

Commander Sansoucy, Lcdr. Sutter, Lt. Hightower
Commander Amphibious Forces, ACOS for Intelligence
San Diego, California

Lcdr. H. Nicholson
Fleet Numerical Weather Center
Monterey, California

Mr. George Anderson
Naval Underwater Warfare Center, Ocean Sciences Dept.
San Diego, California

Capt. W. C. Wells, Lcdr Boehm, Lt. Schuller
Naval Inshore Operational Training Center
Vallejo, California

Mr. Thomas Odum
USN Mine Defense Lab
Panama City, Fla.

Commander Robert Uhwat
OP-701, Development Planning Div., Program Management Branch

Capt. Dombroff
OP-32, Deputy Director Anti-Submarine Warfare & Ocean
Surveillance Division

Mr. Ervin Kapos
CNA, Marine Corps Analysis Group (MCAG)

Mr. L. Heselton (Capt. Ret. USN)
Center for Naval Analysis

Lcdr. John W. Skillman
OP-90D36 Program Information Section

Commander Dave Hurt
OP-322, ASW, Ocean Surveillance Div. Air Section

Lcdr. Eugene Spadoni
OP-605D6, General Purpose Objective Forces
Amphibious Mine Warfare & Operations Officer

Capt. Zimmerman
Head, Mine Warfare Branch

APPENDIX II

BIBLIOGRAPHIES

BIBLIOGRAPHY

A Review of Oceanographic Variables and Their Analyses and Predictions Over the Continental Shelf. Technical Note No. 38. Monterey, California: Fleet Numerical Weather Facility, May 1968.

Baldwin, Ellis, Palmer and Close. Tropicalization of Radio and Radar Equipment. Columbus, Ohio: Battelle Memorial Institute, November 1949.

Bekker, M. G. Introduction to Terrain-Vehicle Systems. Ann Arbor, Michigan: The University of Michigan Press, 1968.

Campbell, R. D. Environment and Logistics, with the assistance of W. H. Bailey, N. R. Mason, and H. W. Westermann. Washington, D.C.: The George Washington University, 15 November 1955.

Chernowitz, G., et al. Environmental Information Control. Report 430-1. American Power Jet Company, February 1961.

Climatic Extremes for Military Equipment. QR&DC, EP Report 146. Washington, D.C.: Department of the Army, Quartermaster Corps, November 1951.

Computer Prediction of Environmental Effects on USAF Materials. Technical Documentary Report No. FDL-TDR-64-107. Ohio: Wright-Patterson Air Force Base.

Design Disclosure for Systems and Equipment, Military Standardization Handbook. MIL-HDBK-226 (Navy), Naval Ship Engineering Center, Washington, D.C. 17 June 1968.

Engineering Weather Data. AFM 88-8, Chapter 6, TMS-785, Department of the Air Force, the Army and Navy. Washington, D.C.: Government Printing Office, 15 June 1967.

Environmental Design Criteria and Other Mutual Geographical Problems. Notes on Conference between WCLDE, WACD, GRD, AFCRC. Massachusetts: Air Force Cambridge Research Center, 8-9 February 1956.

Environmental Stresses and Effects on Military Activities. Final Report, May 31, 1969. Columbia, South Carolina: University of South Carolina, 1969.

Environment Test Methods. MIL-STD-810B. Washington, D.C.: Department of Defense, 23 June 1964.

Fleet Measurement and Use of Oceanographic Temperature - Depth Profiles, Procedures and Recommendations. Study by ASWAC Oceanographic Subcommittee, March 25, 1966.

General Requirements for Environmental Systems, Pressured Aircraft. MIL-E-18927F(WEP). Washington, D.C.: Naval Air Systems Command, December 29, 1961.

General Specification for Environmental Testing, Aeronautical and Associated Equipment. MIL-E-5272C(ASG), Systems Engineering Group. Ohio: Wright-Patterson Air Force Base, April 13, 1959.

Gray, Gilbert R., Duckenfield, Thomas A., and Fuchs, Joseph L. The Navy Automated Research and Development Information System (NARDIS) Progress Report, July 1965, Research and Development Report 2103. Washington, D.C.: Department of the Navy, David Taylor Model Basin, August 1965.

Griffiths, Thomas M., et al. Final Report, Project Duty. Vols. 1-3. Denver, Colorado: Department of Geography, University of Denver, 15 September 1967.

Intelligence. FMFM 2-1, Department of the Navy, U.S. Marine Corps, Washington, D.C

Kesel, Philip G., Lieutenant, USN. "Weather Support for Naval Operations," UnderSea Technology. August 1967.

Kurotori, I. S. and Schafer, H. Storage Temperature of Explosive Hazard Magazines. Part 1, American Desert, November 1966; Part 2, Western Pacific, June 1967; Part 3, Okinawa and Japan, June 1967, Part 4, Cold Extremes, May 1968. China Lake, California: Department of the Navy, Naval Ordinance Test Station, Naval Weapons Center.

McCall, C. H., Jr. The Nine-Coordinate Probability Model Describing Environment-Military Operations Relationships. The Historical Records Project. Washington, D.C.: The George Washington University, September 1957.

Military Specification Demonstration Requirements for Airplanes. MIL-D-8707A(WEP). Washington, D.C.: Naval Air Systems Command, September 1960.

Military Specification Data and Tests, Engineering: Contract Requirements for Aircraft Weapon Systems. MIL-D-8706B(AS).. Washington, D. C.: Naval Air Systems Command, August 15, 1968.

Numerical Computation of Tides and Currents with a Hydrodynamical Model and the Application of Results to Mine Warfare Problems. Technical Note No. 44. Monterey, California: Fleet Numerical Weather Facility, January 1969.

Oceanographic Analyses and Forecasts for Fleet Support (Services and Codes). Technical Memo No. 11-2. Monterey, California: Fleet Numerical Weather Facility, August 1967.

Programming and Application of the Hydrodynamical Numerical Method to Da Nang Bay. Technical Note No. 42. Monterey, California: Fleet Numerical Weather Facility, September 1968.

Robbins, Walter J., McCabe, Arthur T., Schmidt, Edgar J., et al. Environmental Factors in Systems Effectiveness. Technical Report No. RADC-TR-68-199. New York: Rome Air Development Center, Air Force Systems Command, Griffiss Air Force Base, October 1968.

Schafer, Howard C. Environmental Criteria Determination for Air-Launched Tactical Propulsion Systems. Parts 1 and 2, Stockpile-to-Target Sequence, July 1968; Part 3, Description of the Environment, August 1968. China Lake, California: Department of the Navy, Naval Weapons Center.

Spot Retrieval Program. NAVCOSSACT Document No. 60W001 PM-02. Washington, D.C.: Naval Command Systems Support Activity, May 1968.

The FNWF Ocean History Information Retrieval System. Technical Note No. 39. Monterey, California: Fleet Numerical Weather Facility, April 1968.

U. S. Fleet Numerical Weather Facility Activities Relating to Sea-Air Interactions on a Synoptic Scale. Technical Note No. 38. Monterey, California: Fleet Numerical Weather Facility, February 12, 1965.

U. S. Naval Weather Service Computer Products Manual. NAVAIR 50-1G-522. Washington, D.C.: Department of the Navy, Chief of Naval Operations, March 1, 1967.

Weather File Maintenance Program. NAVCOSSACT Document No. 60W001 PM-02. Washington, D.C.: Naval Command Systems Support Activity, May 1968.

Wells, Howard A. "Weapons System Planners Guide," IEEE Transactions of Engineering Management, Vol. EM-14 No. 1 (March 1967) 14-16.

PARTIAL LIST OF RELEVANT BIBLIOGRAPHIES

Air Force Scientific Research Bibliography 1960. AD-647 817. 67-8. FLD. 5/1

An Annoted Bibliography of Protective Structures Research. AD-810 163. 67-10. FLD. 13/13A.

Annual Department of Defense Bibliography (1967) of Logistics Studies and Related Documents. AD-647 872. 67-8. FLD. 11/6. Naval Applied Science Laboratory. Brooklyn, New York (Y).

Bibliography of NOL Technical Documentation. (U) 1967 edition. NOLTR 67-200. U.S. Naval Ordinance Laboratory. White Oak, Maryland. 1 January 1968.

Bibliography of Reports, 1966. AD-648 536. 67-9. FLD. 8/10.

Bibliography of Rock Island Arsenal Technical Documents of 1965. AD-810 799. 67-10. FLD. 5/2A.

Bibliography of Unclassified NRL Formal Reports Numbers 5700 to 6300. RLD Report 6000B. U. S. Naval Research Laboratory. Washington, D. C. January, 1966.

Deep Sea Simulation, Component Testing, and Associated Problems: An Annotated Bibliography. AD-812 899L. 67-12. FLD. 13/4A.

Foundational Research and Independent Exploratory Development Programs. AD-809 007L. 67-9. FLD. 5/14. Naval Air Engineering Center. Philadelphia, Pennsylvania.

Guide to NCEL Technical Documents. Naval Civil Engineering Laboratory. AD644332. Port Hueneme, California. January, 1966.

Quarterly Compilation of Abstracts on Completed Test, Experimental, and Development (TED) Projects. AD-380 212L. 67-11. FLD. 1/1A. Naval Air Test Center. Patuxent River, Maryland.

Quarterly Project Status and Activities Summary. Part I. October-December, 1966. AD-379 416. 67-8. FLD. 5/1A. Naval Weapons Evaluation Facility. Albuquerque, New Mexico.

Report Bibliography. Air Force Rocket Propulsion Laboratory. January 1958 - September, 1966. AD-806 739. 67-7. FLD. 21/8A

Technical Reports Released for Period January Thru December 1966. AD-807 723. 67-8. FLD. 9/5A. Air Force Avionics Laboratory. Wright-Patterson Air Force Base, Ohio.

USNRDL-67-1 An Index to U.S. Naval Radiological Defense Laboratory Technical Reports (TR Series) [illegible] December, 1966. AD-812 215L. 67-11. FLD. 1/2A. Naval Radiological Defense Laboratory. San Francisco, California.

APPENDIX III

LIST OF RECIPIENTS

LIST OF RECIPIENTS FOR #389149

CHIEF OF NAVAL RESEARCH — 2 COPIES
ATTENTION GEOGRAPHY BRANCH CODE 414
OFFICE OF NAVAL RESEARCH
WASHINGTON, D. C. 20360

DEFENSE DOCUMENTATION CENTER — 20 COPIES
CAMERON STATION
ALEXANDRIA, VIRGINIA 22314

DIRECTOR, NAVAL RESEARCH LABORATORY — 6 COPIES
ATTENTION TECHNICAL INFORMATION OFFICER
WASHINGTON, D. C. 20390

CONTRACT ADMIN SOUTHEASTERN AREA
OFFICE OF NAVAL RESEARCH
2110 G STREET, N. W.
WASHINGTON, D. C. 20037

COMMANDING OFFICER
OFFICE OF NAVAL RESEARCH BRANCH OFFICE
BOX 39
FLEET POST OFFICE
NEW YORK, NEW YORK 09510

CHIEF OF NAVAL RESEARCH
ASST. FOR MARINE CORPS MATTERS
CODE 111
OFFICE OF NAVAL RESEARCH
WASHINGTON, D. C. 20360

CHIEF OF NAVAL RESEARCH
CODE 463
SURFACE AND AMPHIBIOUS PROGRAMS
OFFICE OF NAVAL RESEARCH
WASHINGTON, D. C. 20360

COMMANDING OFFICER,
SCIENTIFIC & TECH. INTELLIGENCE CENTER
NAVAL OBSERVATORY, BLDG. 52
WASHINGTON, D. C. 20390

OCEANOGRAPHER OF THE NAVY
OFFICE OF THE OCEANOGRAPHER OF THE NAVY
732 NORTH WASHINGTON STREET
ALEXANDRIA, VIRGINIA 22314

COMMANDING OFFICER
NAVAL RECONNAISSANCE AND TECHNICAL
SUPPORT CENTER
WASHINGTON, D. C. 20390

DR. ROBERT L. MILLER
DEPARTMENT OF GEOPHYSICAL SCIENCES
UNIVERSITY OF CHICAGO
CHICAGO, ILLINOIS 60637

DR. JOHN W. HARBAUGH
DEPARTMENT OF GEOLOGY
STANFORD UNIVERSITY
STANFORD, CALIFORNIA 94305

COMMANDER
NAVAL OCEANOGRAPHIC OFFICE
ATTENTION# LIBRARY (CODE 1640)
WASHINGTON, D. C. 20390

PROFESSOR JOHN D. NYSTUEN
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN 48103

DR. O. M. MILLER
AMERICAN GEOGRAPHICAL SOCIETY
BROADWAY AT 156TH STREET
NEW YORK, NEW YORK 10032

DR. RICHARD J. CHORLEY
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF CAMBRIDGE
DOWNING PLACE
CAMBRIDGE, ENGLAND

PROF. BRUNO ACCORDI
INSTITUTE OF GEOLOGY & PALEONTOLOGY
UNIVERSITY OF ROME
ROME, ITALY

DIVISION OF LAND RESEARCH
COMMONWEALTH SCIENTIFIC AND INDUSTRIAL
RESEARCH ORGANIZATION
P. O. BOX 109
CANBERRA CITY, A.C.T., AUSTRALIA

OFICINA DE INVESTIGATION Y DESARROLLO
MINISTERIO DE MARINA
LIMA, PERU

DEFENSE INTELLIGENCE AGENCY
DIAAP-10A
WASHINGTON, D. C. 20301

DIRECTOR
COASTAL ENGINEERING RESEARCH CENTER
CORPS OF ENGINEERS, U. S. ARMY
5201 LITTLE FALLS ROAD, N. W.
WASHINGTON, D. C. 20315

CENTRAL INTELLIGENCE AGENCY
ATTENTION OCR/DD-PUBLICATIONS
WASHINGTON, D. C. 20505

DR. RICHARD J. RUSSELL
COASTAL STUDIES INSTITUTE
LOUISIANA STATE UNIVERSITY
BATON ROUGE, LOUISIANA 70803

DR. JOHN H. VANN
DEPARTMENT OF GEOGRAPHY & GEOLOGY
STATE UNIVERSITY COLLEGE
1300 ELMWOOD AVENUE
BUFFALO, NEW YORK 14222

DR. EDWARD B. ESPENSHADE JR.
DEPARTMENT OF GEOGRAPHY
NORTHWESTERN UNIVERSITY
EVANSTON, ILLINOIS 60201

DR. WILLIAM C. KRUMBEIN
DEPARTMENT OF GEOLOGY
NORTHWESTERN UNIVERSITY
EVANSTON, ILLINOIS 60201

CHIEF OF NAVAL RESEARCH
CODE 437
INFORMATION SYSTEMS
OFFICE OF NAVAL RESEARCH
WASHINGTON, D. C. 20360

DR. DONN S. GORSLINE
DEPARTMENT OF GEOLOGY
UNIVERSITY OF SOUTHERN CALIFORNIA
LOS ANGELES, CALIFORNIA 90007

DIRECTOR
NATIONAL OCEANOGRAPHIC DATA CENTER
WASHINGTON, D. C. 20390

DR. L. A. PETER GOSLING
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN 48103

Center for Research in Social Systems
The American University
5010 Wisconsin Avenue, N. W.
Washington, D. C. 20016

DR. WARREN C. THOMPSON
DEPT OF METEOROLOGY & OCEANOGRAPHY
U. S. NAVAL POST GRAD. SCHOOL
MONTEREY, CALIFORNIA 93940

DR. ROBERT DOLAN
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF VIRGINIA
CHARLOTTESVILLE, VIRGINIA 22903

COMMANDING OFFICER
NAVY MINE DEFENSE LABORATORY
PANAMA CITY, FLORIDA 32402

COMMANDER
NAVAL ELECTRONICS LABORATORY CENTER
SAN DIEGO, CALIFORNIA, 92152

DR. DUANE F. MARBLE
DEPARTMENT OF GEOGRAPHY
NORTHWESTERN UNIVERSITY
EVANSTON, ILLINOIS 60201

Mr. Walter H. Bailey
Earth Sciences Division
National Academy of Sciences
National Research Council
Washington, D. C. 20418

Assistant Director (Research)
Office of Director of Defense
Research and Engineering
Department of Defense
Washington, D. C. 20301

Professor Rodman E. Snead
Department of Geography
University of New Mexico
Albuquerque, New Mexico 87106

Dr. William Warntz
Laboratory for Computer Graphics
Harvard University
Cambridge, Massachusetts 02138

Dr. H. Homer Aschmann
Department of Geography
Division of Social Science
University of California
Riverside, California 92502

Howard Schafer
Code 45330
Naval Weapons Center
China Lake, California 93555

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)
MATRIX RESEARCH COMPANY

2a. REPORT SECURITY CLASSIFICATION
UNCLASSIFIED

2b. GROUP

3. REPORT TITLE
Design of a Computer-Assisted Coastal Information System

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Phase II (17 September 1968 - 17 September 1969)

5. AUTHOR(S) (First name, middle initial, last name)
Robert D. Campbell

6. REPORT DATE
15 September 1969

7a. TOTAL NO. OF PAGES

7b. NO. OF REFS

8a. CONTRACT OR GRANT NO.
N00014-68-C-0164-P002

b. PROJECT NO.
389-149

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT
This document has been released for public release and sale; its distribution is unlimited.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Geography Branch
Office of Naval Research
Washington, D. C. 20360

13. ABSTRACT Progress on this year's work is summarized in the form of four "lessons learned": (1) there is a good deal of evidence within Navy that environmental impact is a significant factor in effectiveness of naval operations; (2) the interaction focus is with weapons systems; therefore, the basis for understanding environmental impact is naval ecology--the science of the interactions between environment and men-and-machines in discrete naval activities; (3) naval ecology provides the framework which relates the four basic naval functions, and it clarifies the distinctions made between research and development, both of which are relevant in weapons systems terms, but in different fashions; and (4) a coastal information system is such a powerful addition to any organization, serving not only the decision-making process but also the process of developmental change, that it must be carefully developed in accordance with both the scientific structure of naval ecology and the functional and organizational patterns of Navy.

Investigations leading to these lessons led us to postulate: (a) a model of naval ecology, and (2) a description of a theoretical coastal information system. In effect, these models constitute our major findings: (1) that it is possible to begin to build from present knowledge an aggregated and extrapolatable body of information concerning the effect of environment on a given naval operation; and (2) that it is possible now to design and introduce a partial, prototype coastal information system which will produce command level outputs to all four naval functions for an amphibious operation.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Geographical Data Flows						
Priority Output Structure						
Information Exchange (interface)						
Information System						
Geographical Systems						
Naval Ecology						
Environment						
Environmental Impact						
Environmental Effects						
Data Marshalling						
Naval Functions						